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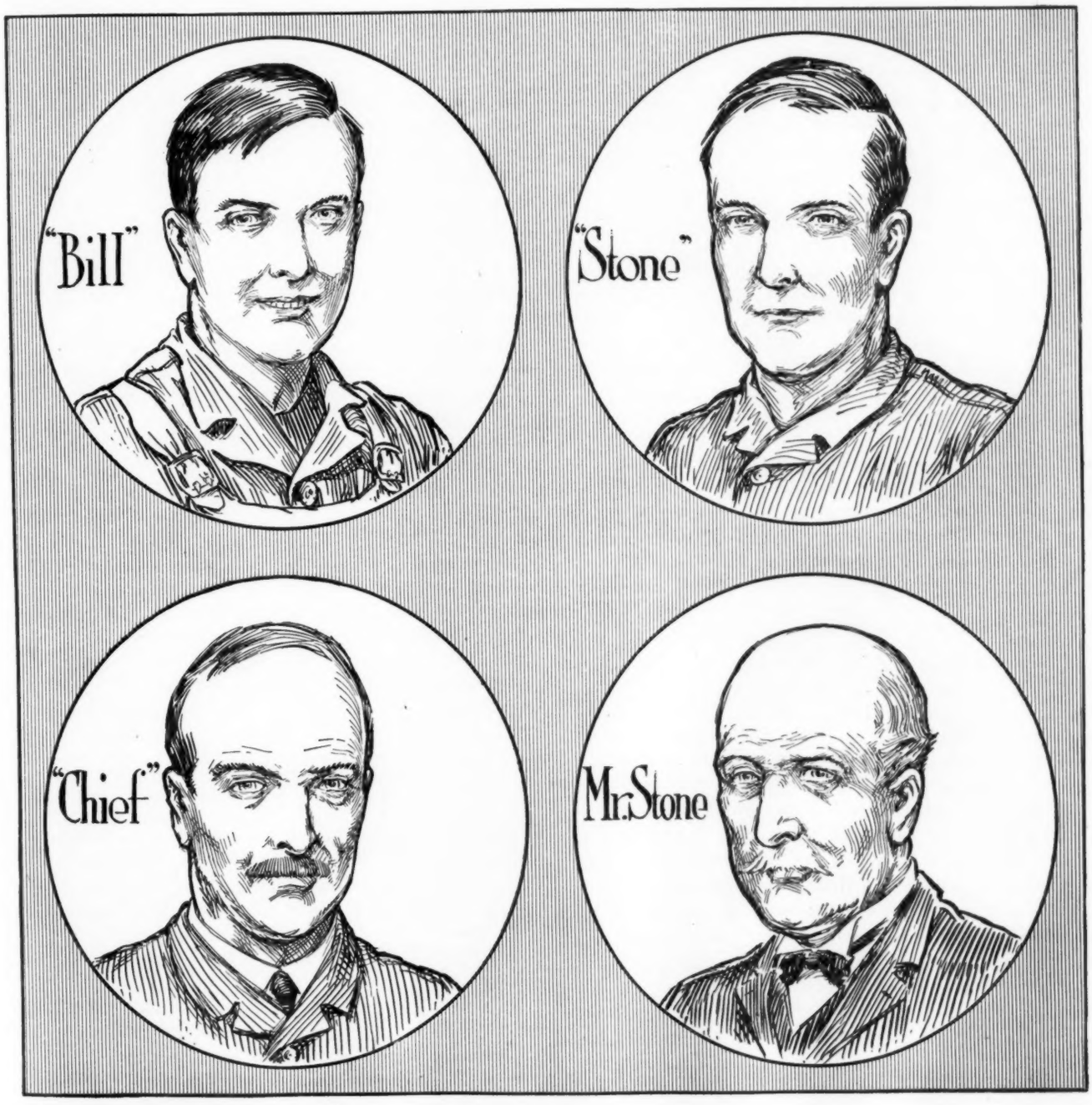


Milestones

Steam Turbines--Their Principles and Operation*

By Charles H. Bromley

SYNOPSIS—The lecture is intended for operating men. It explains in simple words and diagrams how a turbine makes use of the energy in the steam, what impulse and reaction are as applied to turbines, what staging is and why it is necessary; tells in a general way what to do when starting and stopping, and emphasizes the importance of careful attention to the oiling system and the blade clearances.

To understand the turbine it is essential that one be acquainted with the forms of energy of which it makes use. Energy is of two kinds, potential and kinetic. The former is rest energy, or energy capable of manifesting itself by reason of position, as the weight of a pile driver before it is released to descend, as steam under pressure, confined and ready to move on being released, or as a spring compressed or elongated. Things have potential energy by reason of their position or by the state of arrangement of their molecules. Kinetic energy is energy of motion, as the energy in a falling weight, a moving train, a jet of water or steam. When kinetic energy is mentioned velocity is always implied.

The reciprocating engine uses the potential energy in the steam, for the energy is given up by the steam as it expands, pushing the piston ahead of it. The potential energy is converted directly into mechanical work. A turbine changes the potential energy into kinetic before it does work with the steam. It may make the change complete before the steam enters the moving parts of the turbine, or it may make it in installments—in stages.

Difference between Impulse and Reaction

This brings us to the subject of impulse and reaction, that is, to the two ways in which the energy is extracted from the steam at the turbine blades. Impulse action, when related to turbines, means to force, to impel, by impact, as when you wash the floor with water from a hose. The blow, the impact, with which the water strikes the dirt drives it ahead. In an impulse turbine the steam does the same thing to the wheel. Examples of impulse and reaction are shown in Fig. 1. A good illustration of reaction is the common whirling lawn sprinkler shown. The water under pressure flows from the nozzles, causing them to move in a direction opposite that taken by the water. Reaction as applied to a turbine wheel may be explained as a backward push as the steam passing through the nozzles reduces its pressure. The wheels of reaction turbines have blades that form nozzles, and the pressure at the inlet side is greater than that at the outlet. This pressure difference in the wheel is what causes it to revolve. In an impulse turbine the pressure is the same on both sides of the wheel. The two kinds of blading, impulse and reaction, are shown in Fig. 2.

*From a lecture before the Modern Science Club, Brooklyn, N. Y.

Keeping in mind the two forms of energy, it is well now to understand what is meant by staging as applied to turbines. One of the definitions of stage given in Webster's Dictionary admirably suits our needs:

Stage: "A distance between two places of rest on a road; hence, a degree of advance in a journey."

Steam at high pressure enters the turbine, passes through it and comes out with most of its energy extracted. The steam is on a journey, the turbine is the road and the intervals between stages are the places of rest on the way. If the steam passes through the turbine from the high to the low pressure all at once, if it does not rest, as it were, between the two points, if there is but one distance between the beginning and the end of the journey (expansion), then that turbine is a single-stage machine. If the steam rests more than once on the way, then the turbine through which it passes is a multi-stage machine.

In Fig. 3, left, the pressure due to the total head is applied to the wheel. It is a single-stage machine. At the right the total head is divided into four parts. The machine is a multi-stage one. Each wheel has but one-fourth of the total pressure applied to it. The velocity of the water at the nozzles is less in the multi-stage than in the single-stage machine and therefore permits of running the wheels slower, although about the same amount of energy is taken out of the jets in both cases. The advantages of dividing the pressure or velocity drop in this way in steam turbines will be taken up presently. A stage in a turbine may also be considered as a compartment for a wheel where the steam decreases either its pressure or velocity, as shown in Fig. 4.

By properly graduating the cross-section of a nozzle you can expand steam from one pressure to another, making the drop between inlet and outlet as much as desired. Such nozzles form the communicating passages between the stationary and moving blades or between the stages or compartments of a turbine. It is in this way that the pressure and velocity are controlled in the wheels and the stages, or wheel compartments.

Single- and Multi-Staging

Primarily, it is the great amount of energy liberated by the expansion of a comparatively small weight of steam that makes staging in turbines necessary. A pound (weight) of steam at 150 lb. pressure expanded in a perfect nozzle to 1 lb. absolute (28 in. vacuum) gives up 325 B.t.u., which is equivalent to $325 \times 778 = 252{,}850$ ft.-lb. of energy.

In expanding between these two pressures in one jump the steam would attain a velocity of a little over 4000 ft. per second, or more than 2700 miles an hour. Nearly all the energy (potential) that was in the steam before its expansion is present after expansion in the kinetic (velocity) form. To convert the kinetic into mechanical energy the steam must be brought to rest by the turbine wheel or rotor.

In an impulse turbine expansion of the steam occurs only in the nozzles, or stationary blades, and in a single-

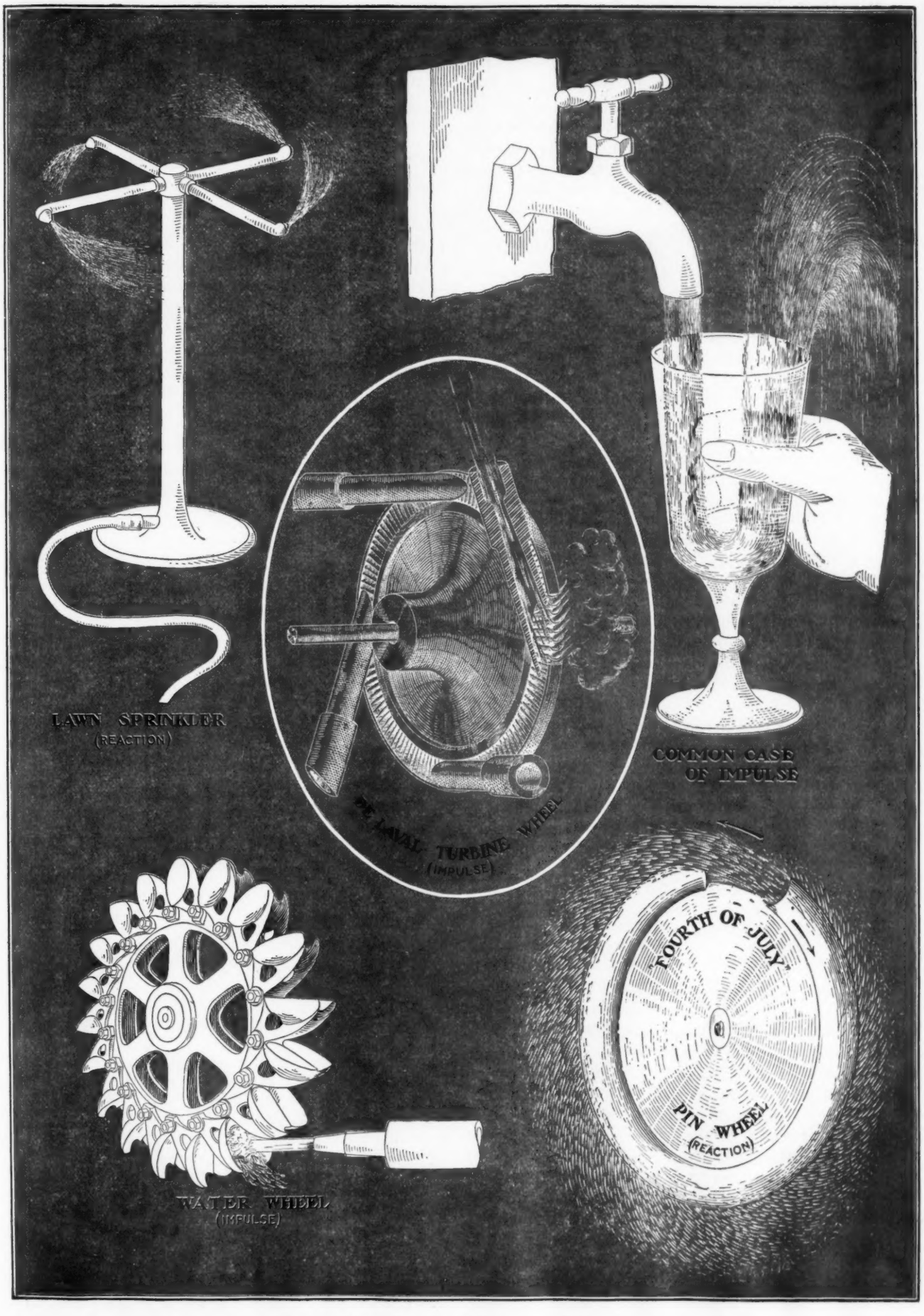


FIG. 1. EXAMPLES OF IMPULSE AND REACTION

stage machine, like the De Laval, Fig. 1, for example, the steam is fully expanded in the nozzles and therefore it strikes the wheel at the enormous velocity of about 4000 ft. per sec.

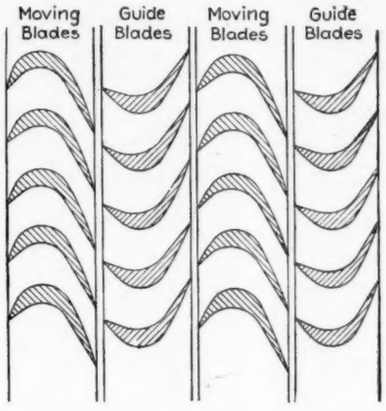
If the glass in Fig. 1 were moved in the same direction as the jet, or stream, of water and at one-half the velocity of the stream, the water would just flow over the side of the glass and all the energy in the jet would be extracted. To bring the steam to rest the wheel must run at half the speed of the steam jet, or, for the single-wheel turbine the peripheral speed of the wheel must be 2000 ft. per sec. Under these conditions the steam would leave the wheel with just enough velocity to force itself away from it. To produce this effect, i.e., to get the steam to leave the bucket with no velocity, means using an enormous wheel if a fairly low number of revolutions per minute is desired, or, if a small wheel is used it must run at an extremely high speed. Mechanical difficulties do not permit of obtaining slow wheel speeds, for the wheel would be too large (64 ft. diameter for 600 r.p.m.), so small wheels running as high as 30,000 r.p.m. are used in the small-sized single-stage De Laval machines. Gears are used to reduce the speed to accommodate the driven machine. About 500 hp. is the capacity limit commercially for a single-stage turbine.

Suppose all the velocity were not extracted by the wheel. Then there would still be energy in the steam which might be applied to another wheel and from the second to a third and then to a fourth, all on the same shaft; and so on until the pressure and velocity, and therefore the energy, were zero. With a suitable number and arrangement of wheels, nozzles and diaphragms (partitions forming the stage compartments) the pressure and velocity changes through the turbine may be controlled as desired. On page 630 the diagrams, Figs. 5, 6, 7, 8, and 9, show the different methods of extracting the energy from the steam. The page will make a good insert for your notebook. The tendency here and abroad is toward the wider adoption of the "composite" design, i.e., velocity staging in the high-pressure end and pressure staging in the low-pressure end. A good illustration of this design is shown in Fig. 9. Note the large drop in pressure in the impulse, or velocity, chamber.

For a simple and entertaining explanation of steam speeds and bucket speeds the reader is referred to the article by F. R. Low in last week's issue.

Starting and Stopping

When steam is turned into an engine it fills the space back of the piston and in some cases the whole cylinder, warming it uniformly and therefore minimizing strains due to expansion. In most large turbines steam would not be admitted around the whole circumference of the rotor when the turbine was standing still unless special "warming pipes" were provided, as they sometimes are. So, to warm a turbine, large or small, it is always best to have all drains open and admit steam quickly enough to revolve the turbine, letting it warm while running. If allowed to stand still with warming steam on, the steam will flow along through the blading in a path, thus creating unequal expansion of, and imposing objectionable strains in, the rotor and casing. If the sealing-gland water is admitted under pressure created by a pump, a tank or from the city mains the turbine may be started condensing. If the gland-seal water pressure is created by an impeller on the shaft whose speed is that of the rotor, and there is no means of sealing, then it is best to start noncondensing, putting the condenser in service slowly after the turbine has attained normal speed. In this way excessive amounts of air are not carried into the machine. Turbines using steam-sealed carbon-ring packing may be started condensing. It is



Cross-Sections of Turbine Blades

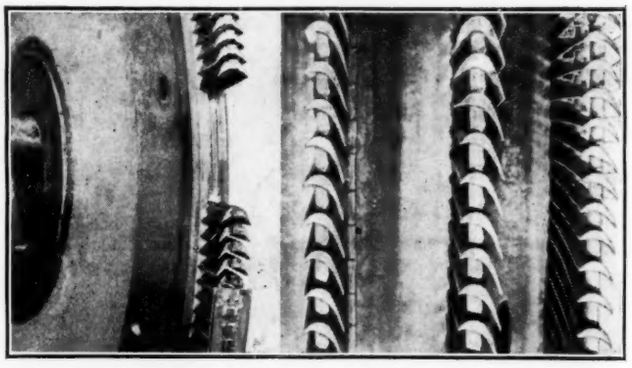


Fig. 2. Impulse and Reaction Blading for Turbines

good general practice to shut down the condenser quickly when stopping a turbine, for with some designs of gland seals cold air would be drawn in when the steam was shut off the machine if the condenser were left running, exposing the rotor to distortion, which is objectionable.

Turbine Lubrication

Lubricating oil for large turbines, vertical or horizontal, is supplied under pressure, the oil being forced by at least two pumps, one driven by the turbine shaft, the other a small, usually duplex, steam-driven pump. The latter should be started before the turbine is turned over to in-

sure good circulation for starting. When the turbine is up to about normal speed the shaft-driven pump goes into useful service and the steam-driven one may be stopped. When shutting down, start the steam-driven pump and let it run until the turbine stops. Sometimes an elevated tank is used for supplying oil for starting and stopping. The aim always should be to have the oil and the oil-cooling water circulating before starting, and continue flowing without cessation until the machine is at a standstill. This is important.

The importance of a continuous oil supply to the bearings of a turbine is much greater than for a reciprocating engine. This is because of the small clearances between the stationary and rotating parts, because the speed is much greater, and because the bearings are near the high-temperature parts of the machine. All of these conditions make a hot bearing much to be feared. Should the babbitt or white metal in the bearings reach the melting point and become plastic, the rotor will drop, owing to its weight, and if not stopped in time many blades may be ripped off, and if it is a single-flow Parsons-type machine the dummy pistons and rings will be seriously damaged. The oil circulation system—the reservoir, the pumps, the filter,

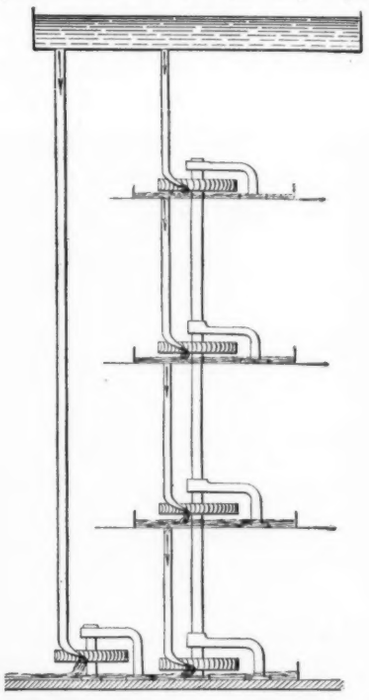


FIG. 3. INSTEAD OF APPLYING THE TOTAL PRESSURE ON ONE WHEEL (ONE STAGE), THE MULTI-STAGE MACHINE USES MORE THAN ONE WHEEL, APPLYING ONLY PART OF THE TOTAL PRESSURE ON EACH

the cooler, the pipe lines and the oil grooves—must be given the most thorough attention.

As the oil consumption of turbines is low on account of no oil getting in contact with steam or condensate, and because of the circulation system, it is good engineering to use a high-grade mineral oil, free from acids, thickeners, tarry, slimy and saponifiable substances. The General Electric Co. recommends that the flash-point, open-cup test, should be below 334 deg. F. and that the viscosity should not be more than 228 sec. at 40 deg. C. (104 F.), as shown by a Saybold viscosimeter, which is the kind used by the Standard Oil Co.

Good general instructions for starting are: Have all glands sealed at about 5 to 10 lb. pressure; the atmospheric or free exhaust valve is usually water-sealed. Have it sealed. Have the oil circulating through the bearings. If the turbine is a Curtis vertical, start the step-bearing and valve-gear pumps and maintain the necessary pres-

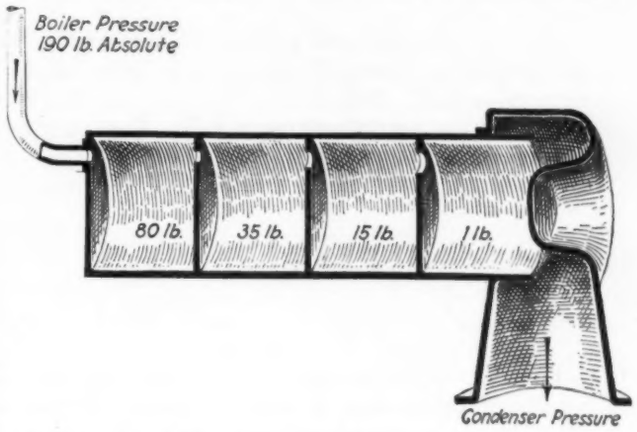


FIG. 4. TURBINE STAGING CONCEIVED OF AS COMPARTMENTS

Note that the openings between compartments increase from the high- to the low-pressure end to pass the increasing volume of steam.

sure—750 to 1500 lb. on the bearing, depending on the size of the turbine. Now start the dry-air pump, the hot-well pump and the circulating pump. Usually, there is a pipe leading from the condenser to the top of the circulating pump. Open the valve in this line (priming line), as it allows air to be exhausted from the pump and suction and assists the pump in picking up its water. Slowly bring all pumps up to speed. If there are drains for the different stages of the turbine, open them. Now start the main turbine slowly, increasing the speed and letting the governor get control.

Look around to make sure that the oil and water circulation is good, that the circulating-water pressure and step-bearing oil or water pressure are right, and that the governor has control. Next close the circulating-pump priming valve. Now put on the load. If there are steam-sealed glands, shut off the steam to the high-pressure packing, for the pressure in the first stage prevents air getting in. It may be necessary to regulate the pressure on the low-pressure packing. Now close the drains of the stages. The gear may then be oiled. The main turbine may vibrate considerably while being brought up to speed. Do not be alarmed at this. When this occurs admit a little more steam quickly to get the rotor above the "critical speed," when the vibration will ordinarily cease. Acquire the habit of shutting down the turbine by tripping the emergency governor, which should automatically operate at 10 to 12 per cent. above normal speed.

Sometimes, just after the machine gets its load it will lag, i.e., be slow or "jerky" with its speed. Frequently, this is due to the pilot valve for the main steam-admission valve sticking, owing to carbon which has collected on the stem. Pour on some kerosene for the time being, but clean the valves as soon as the unit is stopped. In case of any unusual disturbances inside the casing, as the noise due to rubbing of the blades, trip the emergency governor to avoid serious damage or, perhaps, a wreck.

For best economy the clearances between the tips of the blades and the casing and between the sides of the station-

PRESSURE AND VELOCITY CHANGES IN STEAM TURBINES

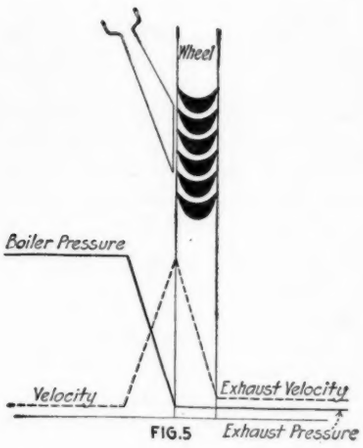


FIG.5

Fig. 5. Pressure and velocity changes as they occur in single-stage turbines, which type most small turbines represent. Notice that the pressure drops completely in the nozzle and the velocity completely in the moving wheel.

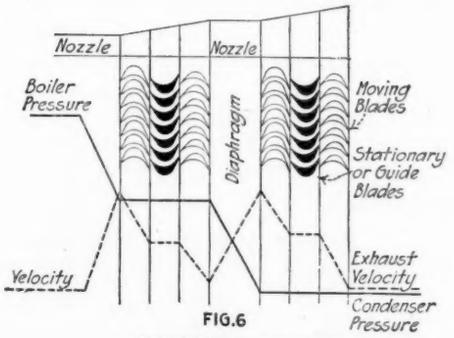


FIG.6

Fig. 6. Multi-pressure, multi-velocity staging. The pressure in each stage is constant, but is dropped in a nozzle before each stage. Large Curtis vertical machines use the energy in this way. The turbine is an impulse machine.

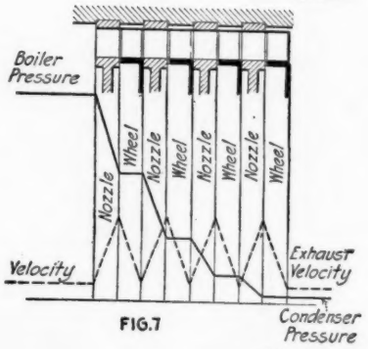


FIG.7

Fig. 7. Pressure and velocity changes as carried out in the multicellular (impulse) type. This kind of turbine is a multi-pressure, single-velocity machine, of which some of the De Laval, Zoelly, Kerr, Rateau and others are representative types.

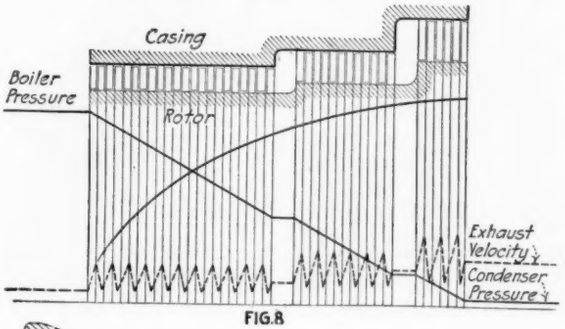


FIG.8

Fig. 8. Shows how the "pure" reaction, or Parsons, types of turbines use the energy in the steam. The pressure is dropped very gradually through many rows of blades, there being no large increase in velocity anywhere in the machine.

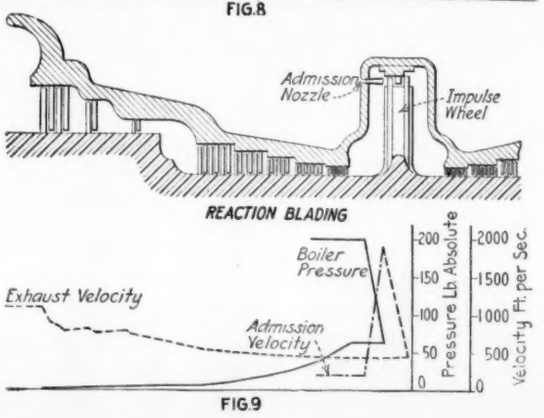


FIG.9

Fig. 9. Pressure and velocity changes as made in the composite design, with velocity staging in the high-pressure element and pressure staging in the low-pressure element. The diagram relates particularly to the Westinghouse double-flow turbine. Many turbines here and abroad are of the composite design.

ary and the moving blades, and between the dummy pistons and their rings, if a single-flow Parsons-type machine, must be small, a comparatively few thousandths of an inch in all cases. Because of the high speeds at which turbines run and because of the small clearances, it is essential that the rotor be in mechanical balance. Adjusting clearances and putting a rotor in balance are jobs requiring skill carefully applied. Time does not permit of taking up these subjects in this lecture, though they are of much interest and importance to the operating engineer.

Steam-Generating Methods, Cleveland Municipal Plant

By A. D. Williams

SYNOPSIS—This large central plant uses economizers. The gates in the hopper outlets of the coal bunker are opened and closed by compressed air, the control being in the hands of the coal-telpher operator. Delray-type boilers are used. Stoker and draft controls are interesting.

In designing the new, or East Fifty-third Street Cleveland municipal lighting plant, F. W. Ballard has used motor-driven auxiliaries throughout, but has provided a steam-driven boiler feeder and a turbo-exciter for emergency service. This plan has simplified the piping systems and eliminated the exhaust steam feed-water heater. Large-sized, high firebox boilers are used, with induced- and forced-draft fans, and the waste gases from the boiler are passed through an economizer for heating the feed water.

The plant is on the shore of Lake Erie at the foot of a steep bluff on the top of which are the tracks of the Lake Shore R.R. and a siding from which two spurs extend over the coal bunker. The height available at this point was not sufficient to permit of placing the bunkers above the boilers without excavating to a considerable depth below the water level of the lake. As the result of this condition, the station practically consists of three parallel structures—the coal-bunker section on the east, the electrical section on the west and the boiler section in the center.

The bottom of the bunker consists of 40 steel-plate hoppers, each provided with a gate opened and closed by a compressed-air cylinder whose operation is controlled by the coal-telpher operator. The telphers run on transverse tracks below the east section of the bunker and are carried by a transfer crane below the west section, an arrangement which permits coal to be drawn from any section of the bunker and delivered to any boiler. Each telpher is provided with a weighing hopper, and the operator on each watch turns in a report of the amount of coal and the time at which coal was delivered to each boiler.

Fig. 1. Aisle below Bunker Showing Hopper Bottom with Air-Operated Gates for Loading Telpher

The present installation comprises five Delray-type Stirling boilers, each fired by two six-retort Taylor stokers. Exceptionally large structural-steel coal hoppers are provided for each stoker, from which the coal flows by gravity to the grates. The central space between the two stokers is closed by dump plates, from which the ashes and clinker are dropped into an ashes hopper. An industrial track is laid in the concrete floor of the boiler-room basement, and upon this are operated steel side-dump ash cars and a storage-battery-operated electric ash car. These cars are used to carry the ashes outside of the building to a point where they can be used in filling in and extending the city property to the harbor line established by the United States engineers.

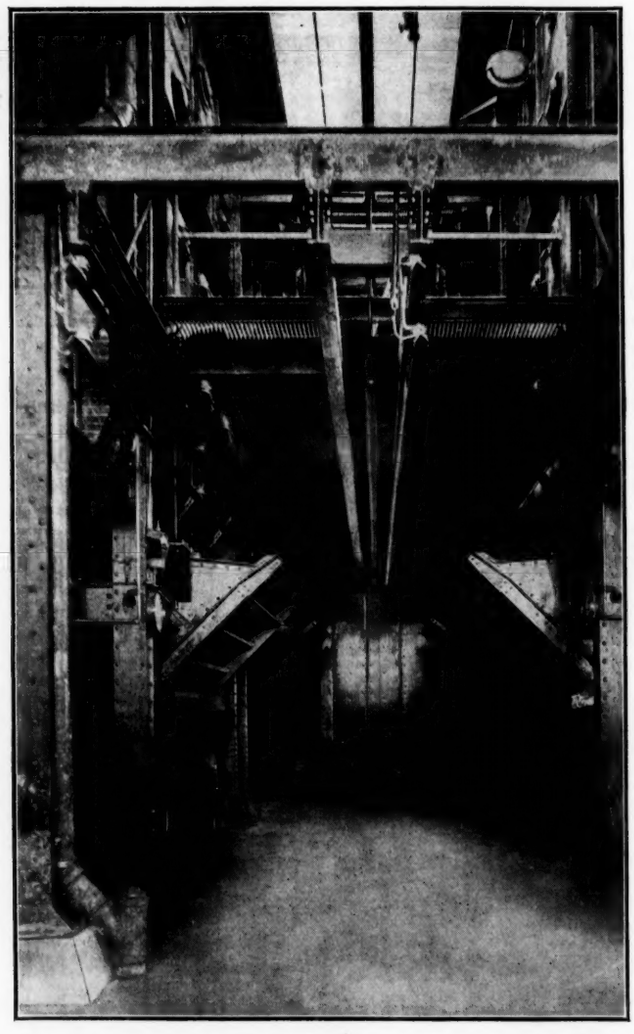


FIG. 2. FIRING AISLE. NOTE LARGE STOKER HOPPERS

The fire area below the boiler is approximately 200 sq.ft., for an average height of about 10 ft. to the bottom of the two mud drums. From this height up the combustion chamber is shaped like a wedge, point up, with a height of nearly 20 ft., the two sloping sides being formed by the tubes of the first pass. This arrangement gives ample space for the flame to form, and the combustible gases are not chilled below the igniting temperature by the comparatively cold tubes of the boiler. In operation the interior of this chamber shows a clear white flame at the lower portion and transparent orange above. As one pound of gas occupying a unit volume in the blast main will occupy five volumes in the combustion chamber and one and one-quarter volumes at the uptake, there are some reasons for providing space for this expansion. The second pass of the gases brings them in contact with the superheater tubes, and at the end of the third pass they flow into an overhead smoke flue. On test the gas temperatures at this point ranged from 510 deg. F. at 106 per cent. rating to 832 deg. F. at 273 per cent. rated load.

In this plant the stokers and the forced-draft fans are operated by separate motors. The speed of the fan motors is governed by controllers operated by changes in boiler pressure, while that of the stoker motors is controlled by changes in blast pressure. The small houses which protect these speed controllers are shown at the left side of the aisle in Fig. 2. Additional control of the draft is supplied by the induced-draft fans, which are operated by motors with manual speed control by means of which the boiler tenders can keep the combustion chamber close to or slightly above atmospheric pressure. This method of operation obviates any tendency of air to seep into the settings through the brickwork or around the cleanout doors and is particularly desirable when it becomes necessary to bar the fires, as there is no tendency to either chill the furnace or burn the firemen. In practice this plan seems to work out well.

From the boilers the waste gases are carried to the economizers and the stack by sheet-steel flues. The stack provided is not designed to supply draft, and for that

PRINCIPAL STEAM GENERATING EQUIPMENT OF EAST 53RD STREET STATION, CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	Stirling, Delray type	10,134 sq.ft. heating surface	Steam generation	225 to 275 lb. pressure; 125 deg. to 150 deg. F. superheat	Babcock & Wilcox Co.
10	Stokers	Taylor underfeed	6 retort	Under boilers	From standby to 275 per cent. boiler rating	American Engineering Co.
6	Motors	Variable speed	10-hp	Stoker drive	725 to 1125 r.p.m., 220 volts, 37.5 amp., direct current	Diehl Mfg. Co.
6	Speed controllers	Pressure controlled	10-hp	Stoker drive	220-volt	Cutter-Hammer Mfg. Co.
6	Speed controllers			Stoker drive	Controlled by air duct pressure	Mason Regulator Co.
	Operators					
5	Fans	Multivane	36,000 cu.ft. air per min	Forced draft	7 in. of water pressure	B. L. Sturtevant Co.
5	Fan motors	Variable speed	75-hp	Forced draft	600 to 730 r.p.m., 220 volts, 282 amp., direct current	Allis-Chalmers Mfg. Co.
5	Speed controllers	Pressure controlled	75-hp	Forced draft fans	220-volt	Cutter-Hammer Mfg. Co.
5	Speed controllers			Forced draft fans	Controlled by boiler pressure	Mason Regulator Co.
	Operators					
2	Fans	Steel housed	16x7-ft	Induced draft	Belted to motors; 70 to 210 r.p.m.; 101,000 to 325,000 cu.ft. per min.; 1 in. draft at economizer inlet	Green Fuel Economizer Co.
1	Fan motor	Induction, variable speed	200-hp	Induced draft	695 r.p.m.; 3-phase; stator 2300 volts, 47.5 amp.; rotor 479 volts, 207 amp	Allis-Chalmers Mfg. Co.
1	Fan motor	Variable speed	200-hp	Induced draft	540 to 740 r.p.m., 220 volts, 745 amp	Allis-Chalmers Mfg. Co.
1	Speed controller	Manual	200-hp	Induced draft		Cutter-Hammer Mfg. Co.
1	Economizer		2 sections in multiple, 27,000 sq.ft. heating surface	Feed water heater	Waste gases from boilers	Green Fuel Economizer Co.
1	Scraper motor	Induction	3-hp	Economizer soot scrapers	1200 r.p.m., 3-phase, 60-cycle, 220 volts	General Electric Co
1	Scraper motor	Induction	7.5-hp	Economizer soot scrapers	1200 r.p.m.	
1	Chimney	Concrete lined	13-ft. diameter, 150 ft. high	Removal of waste gases	Induced draft	General Concrete Cons. Co.

reason has been made only of a height sufficient to carry the waste gases up to a point at which they will not become a nuisance to neighboring property. The two induced-draft fans are close to the base of the stack and discharge into it, each being of a capacity sufficient to handle all the load.

The normal operation of this plant provides for the heating of the feed water by the economizers. This installation is divided in two sections, each containing 824 twelve-foot tubes, the total heating surface in both sections being 27,000 sq.ft. Each section of the economizer can be operated independently or may be cut out by dampers. A bypass flue is also provided to lead the waste gases direct to the induced-draft fans.

SPACE AND VOLUMETRIC DATA OF THE STATION

Turbine room and switch gallery	8100 sq.ft.
Sq.ft. per normal kw	0.54
Sq.ft. per maximum kw	0.36
Boiler room	9230 sq.ft.
Sq.ft. per boiler hp. installed	1.82
Sq.ft. per boiler hp. (6 boilers)	1.52
Sq.ft. per kw. normal	0.615
Sq.ft. per kw. maximum	0.410
Boiler room plus bunker space	15,330 sq.ft.
Sq.ft. per boiler hp. installed	3.02
Sq.ft. per boiler hp. (6 boilers)	2.52
Sq.ft. per kw. normal	1.024
Sq.ft. per kw. maximum	0.682
Total ground area of station	25,360 sq.ft.
Sq.ft. per kw. normal	1.68
Sq.ft. per kw. maximum	1.13
Volume turbine room and switch gallery	500,000 cu.ft.
Cu.ft. per kw. normal	33.33
Cu.ft. per kw. maximum	22.22
Volume boiler room	567,000 cu.ft.
Cu.ft. per boiler hp. installed	11.19
Cu.ft. per boiler hp. (6 boilers)	9.34
Cu.ft. per kw. normal	37.80
Cu.ft. per kw. maximum	25.20
Volume boiler room plus bunker space	841,000 cu.ft.
Cu.ft. per boiler hp. installed	16.55
Cu.ft. per boiler hp. (6 boilers)	13.85
Cu.ft. per kw. normal	56.10
Cu.ft. per kw. maximum	37.40
Volume of building	1,420,000 cu.ft.
Cu.ft. per kw. normal	95.00
Cu.ft. per kw. maximum	63.20

The present installation comprises:

3 main generating units, normal rating	5000 kw. each
maximum rating	7500 kw. each
Five boilers, each having 10,134 sq.ft. heating surface. Space has been left for a sixth boiler.	
Coal storage capacity in bunker	3400 tons
Coal storage per boiler hp.	1114 lb.
Coal storage per kw. normal	454 lb.
Coal storage per kw. maximum	304 lb.

The total length of the economizer is 55 ft. 7 in. and it is so designed that the free area between the tubes is reduced as the gases become cooler.

ECONOMIZER DATA

Number Sections	Number Headers	Tubes per Header	Tubes per Section	Total Number Tubes	Free Area Each Section, sq.ft.	Total Free Area Both Sections, sq.ft.
2	16	6	96	192	56.7	113.4
2	16	8	128	256	49.9	99.8
2	60	10	600	1200	42.9	85.8
2	92	..	824	1648	....	.....

Under present conditions only five boilers are installed and there are 4.75 sq.ft. of economizer heating surface per nominal boiler horsepower. When the sixth boiler is in place this will be reduced to 4.44 sq.ft. At present the station is operating considerably below its capacity, and only one section of the economizer is in use at a time. Owing to this condition it is not fair to present the operating results obtained.

[As told in other issues of POWER describing other features of this plant, the station is the largest municipal electric plant in the United States.—EDITOR.]

What Causes the High Efficiency of Locomobiles?

BY E. R. PEARCE

To what is the high efficiency of the locomobile mainly due? Some are under the impression that it is due to there being practically no steam pipe between the engine and boiler to cause radiation and condensation. This opinion does not appear to carry much weight when one considers that there are many independent engines working with the steam conditions at the cylinder, both as to temperature and dryness, the same as on the locomobile and yet not having anything like its high efficiency.

In the locomobiles the engines are of the piston-valve type, identical in all respects except for a few minor details. Some of these sets, as built by Wolf and Garrett, have the high- and the low-pressure cylinders placed on the boiler at the firebox end, side by side, and are simply jacketed with live steam at boiler temperature, so that any flow of heat through the high-pressure cylinder walls due to the superheat is not lost, but is taken up by the jacketing steam, eventually passing back into the engine.

That which appears to be the biggest factor in securing high economy is the resuperheating of the steam between the cylinders. There seems to be very little difference in the results obtained whether the cylinders are arranged as mentioned, and steam jacketed, or in tandem, with the high-pressure cylinder jacketed by flue gases. This alone tends to point to the gain being derived in the reheating, thereby preventing condensation in the low-pressure cylinder, which is undoubtedly responsible for the bad performances given by many well-designed engines.

On the smaller sizes there is no reheater, the low-pressure cylinder being jacketed with live steam. Usually, these are very efficient, but do not come up to those having reheating. In the latter type the consumption shows marked reduction as the superheats increase, which, in the case of a Wolf engine of the tandem type rated at 60 hp., is as follows:

I	
Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	340.0C
Temperature of steam entering the low-pressure cylinder	171.0C
Superheat entering the high-pressure cylinder	151.9C
Superheat entering the low-pressure cylinder	57.9C
Steam consumption at 43.2 b.hp.	10.9 lb.
II	
Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	360.0C
Temperature of steam entering the low-pressure cylinder	191.0C
Superheat entering the high-pressure cylinder	172.9C
Superheat entering the low-pressure cylinder	71.4C
Steam consumption at 55 b.hp.	10.29 lb.

The difference in the two cases is undoubtedly due more to the increased superheat than to the heavier load, as after the half-load point has been reached the consumption is nearly constant. Like the locomotive, the greater part of the evaporation takes place at the firebox, but averages about 4 lb. per sq.ft. for the total heating surface. This type of boiler has two other strong points in its favor—there is no chance of leaky brickwork, and the end plates and tubes being removable for cleaning purposes, all parts are easily examined and kept in order.

The question now arises as to whether like results could not be obtained on well-designed existing engines by introducing a reheater between the high- and low-pressure cylinders and carefully lagging them, assuming that the gain in efficiency would warrant the expenditure.

Hill-Tripp Centrifugal Pump

The Hill-Tripp Pump Co., of Anderson, Ind., has recently placed on the market a centrifugal pump designed for a number of uses. One- to six-stage pumps are made with capacities ranging from 10 to 20,000 gal. per min., and these pumps are designed to pump against heads of from 10 to 1000 ft. The double-suction single-stage pump is designed for a maximum head of 300 ft. and multistage pumps for heads up to 700 ft. For higher pressures an extra heavy multistage pump is built.

The special feature of these pumps is the impeller, with sides extending a certain distance beyond the vanes, as shown in Fig. 1. The passage formed between the two sides beyond the vanes is flared out, increasing gradually to larger area. In all centrifugal pumps the water leaves the vanes in a tangential direction and at practically the circumferential velocity of the wheel at the extremity of the vanes. This being the case, the relative velocity between the extended sides of the impeller and the water is low and, as a consequence, there is little friction. The shape of the extended sides of the impeller is much the same as the secondary part of a venturi tube, with the added advantage that the tube travels with the water. Owing to the design the velocity head of the water is transformed into pressure before the water leaves the impeller, and as it passes out into the casing the movement of the water is slower than in the suction or discharge pipes. The loss occasioned by stationary vanes is obviated and, consequently, an efficiency as high as 72 per cent. is claimed for these pumps.

As indicated in the drawing at the left of Fig. 1, single-stage pumps have a newly patented balancing device consisting of a central rib in the pump casing, which will deflect the water discharged by the impeller in such a way as to cause increasing or decreasing pressure in the two sides of the casing. If the impeller should move to the left the pressure would increase on the same side and force the impeller in the opposite direction, or *vice versa*. In other words, the pressure against the two sides of the impeller must balance and hold the rotating element in a central position.

For the multistage pump a hydraulic device has been adopted of the general type commonly employed by builders of multistage pumps, with the exception that the present arrangement is double-acting. As shown in Fig. 2, a piston with a renewable ring is secured to the shaft and rotates with the impeller. A pressure chamber is located between this rotating piston and a stationary part, also provided with a renewable ring opposing the ring on the piston. Through a running clearance between the stationary part and a covered sleeve on the shaft, water from the high-pressure end of the pump gradually finds its way into the balancing chamber.

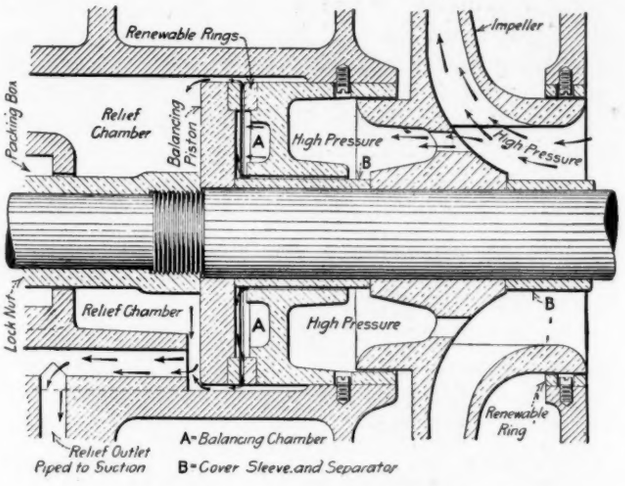


FIG. 2. DETAILS OF BALANCING DEVICE

Eventually, the pressure in this chamber builds up enough to force the rotating piston away from the stationary element. In this way a circular passage is opened up between the rings, and water flows from the balance chamber to the relief chamber behind the piston. The relief chamber is connected with the suction of the pump, as indicated in the drawing. As the water escapes between the rings the pressure in the balance chamber is reduced until a balance is established. A thin film of water is maintained between the rings, and the rotating parts float continuously at a certain distance from the stationary element. The balancing chamber is made large enough to care for large differences in pressure, which in high-lift pumps may amount to several

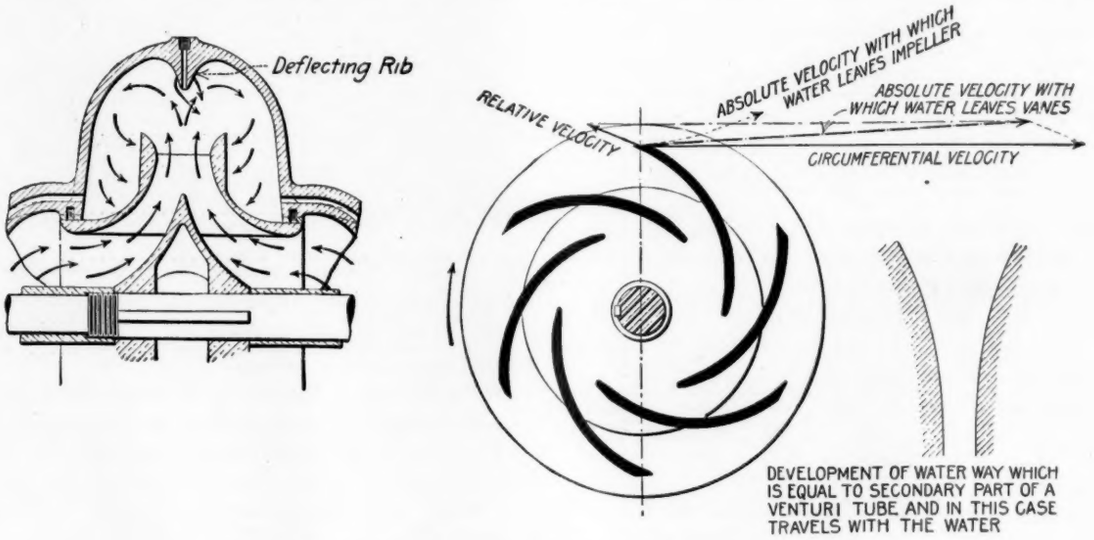
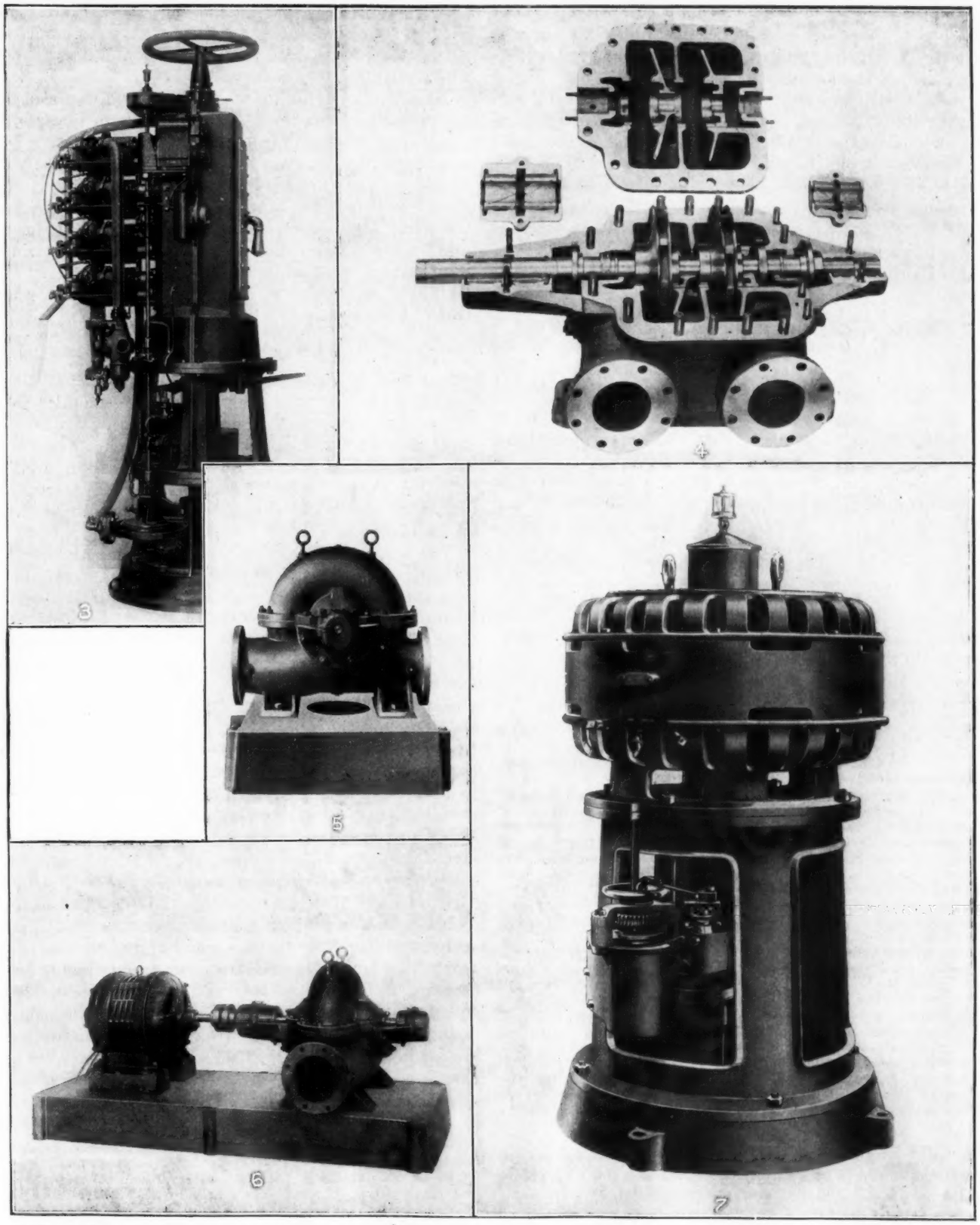

Deflecting Rib
RELATIVE VELOCITY
ABSOLUTE VELOCITY WITH WHICH WATER LEAVES IMPELLER
ABSOLUTE VELOCITY WITH WHICH WATER LEAVES VANES
CIRCUMFERENTIAL VELOCITY
DEVELOPMENT OF WATER WAY WHICH IS EQUAL TO SECONDARY PART OF A VENTURI TUBE AND IN THIS CASE TRAVELS WITH THE WATER

FIG. 1. SHOWING SPECIAL FEATURES OF IMPELLER DESIGN



FIGS. 3 TO 7. SHOWING VARIOUS APPLICATIONS OF THE PUMP TO DEEP-WELL HEAD, HIGH-LIFT CENTRIFUGAL PUMP, AND VERTICAL DISCHARGE HEAD, MOTOR DRIVEN

tons. It has been found desirable to make this provision in spite of the fact that each impeller is itself hydraulically balanced independently of the balancing system.

Should the piston have a tendency to move too much toward the relief chamber, it will approach the outlet to the suction of the pump and automatically reduce the amount of water escaping. The pressure in the relief chamber will then build up and force the piston in the opposite direction, relieving the outlet and again establishing a balance.

Figs. 3 to 7 show a variety of applications of the

pump. Fig. 3 is a deep-well pump head equipped with a four-cylinder high-speed oil engine, fitted with an automatic cutoff for control in case the pump loses its suction or the load is dropped for any reason. Fig. 4 shows a standard multistage high-lift centrifugal pump with the upper half of the casing removed. The construction of the impeller and the balancing and relief chambers is clearly shown in this view. Fig. 5 is a side view of the double-suction impeller split-case centrifugal pump, and Fig. 6 shows the same pump directly driven by an electric motor. Fig. 7 shows a vertical discharge head equipped with a motor for driving and a hard oil pressure pump.

The Government as a Buyer of Power

By A. P. Connor

Some of the conditions of the contract under which the United States Government buys electric current within the District of Columbia are given herewith.

Schedule No. 1 provides that for a monthly current consumption up to 3200 kw.-hr. the rate shall be 6c. per kw.-hr.; up to 4545 kw.-hr., 5½c.; 7500 kw.-hr., 5c.; 12,500 kw.-hr., 4½c.; all current in excess of 12,500 kw.-hr. per month, 3c. But separate buildings (not connected by a covered passageway) must be metered separately, so that the total current used in a group of detached buildings occupied by one department might entitle that department to the minimum rate, yet by the separate metering process the maximum rate would be collected. Schedule 4 is a work of art, as will be seen by careful reading.

SCHEDULE NO. 4—FOR BUILDINGS WHERE PRIVATE GENERATING PLANTS ARE NOW INSTALLED

For electricity used during months from April to September, inclusive, $0.025 per kw.-hr.

This service to be entirely optional with the Government, and will become operative only upon the written request or authority of the particular department or governmental establishment desiring it, and it will be furnished only during the period from Apr. 1 to Sept. 30, inclusive, or for such portion thereof as the service may be required; in cases where service is furnished under Schedule No. 4, during the period from July 1 to Sept. 30, inclusive, or any part thereof, and where any service is required from the contracting company at any time during the period from Oct. 1 to Mar. 31, inclusive, the charges for the service furnished during the period from Oct. 1 to Mar. 31 shall be in accordance with Schedule No. 1, 2, 3 or 5, as may be applicable and selected by the Government, and the charges for the service furnished during the period from July 1 to Sept. 30 shall be adjusted to conform to the rates of charge in force during the period from Oct. 1 to Mar. 31, or any portion thereof, and the contracting company shall be paid the full amount of the difference. Schedule No. 4 is not to be available during the period from Apr. 1 to June 30, inclusive, for buildings where any service has been required during the period from Oct. 1 to Mar. 31, inclusive.

By the terms of this schedule, suppose during the six summer months current to the moderate total of $2500 had been used at the 2½c. rate, and that during the winter for a short period (a single day) it became necessary to obtain current from the electric service company, the only such contractor in the field, the answer according to the schedule would be: "Yes, we will furnish you the current (service lines already in) for 6c. per kw.-hr. provided you pay a penalty of $3500 for having taken current from us during the summer (which we were glad to sell at that time of the year) at 2½c. per kw.-hr."

It seems beyond the belief of a reasonable person that such rates have been approved by the Government. This is probably the most flagrant case of a contract unfavorable to the Government that can be found, and since it has existed for a long period there is reason to believe that it may be continued for many years.

Is it advisable for the engineer of a department to accept and insist on the 2½c. rate (after the apparently sincere advice of an official close up to the Secretary not to attempt to save money for the Government at the risk of his personal welfare and possibly his position), or should he permit the handing over of more than double the money for the service during the summer in order to avoid the personal risk? If he succeeds in the saving, what is there to it for him except "art for art's sake?" If he fails to get through the winter without a holdup, what then? Perhaps a little light obtained in a court proceeding in a test case in which the subject matter was the rate and the apparently piratical charge for back service, would clear up the situation. It has been established beyond a doubt that 2c. a kilowatt-hour is a familiar rate of the same utility for current in buildings in the immediate vicinity of Federal buildings. The rates which the same utility charges other parties is a matter of record with the Public Utility Commission of the District of Columbia (and easily obtainable), and under the control of the Government.

The time of the day in which the greater part of the current is used by the Federal departments is certainly favorable to a central station carrying a substantial commercial and street-railway load, and in this case the utility has one of its power stations located most centrally with respect to the governmental buildings and departments.

The State Department recently rented a certain hotel building and by means of a few feet of conduit and rewiring, it was possible to get power (electrically) from the plant of the State, War and Navy Building at a cost of about $30 a month, but the Comptroller of the Treasury decided that there was no authority of law for extending the government service or system to a "private building," although the hotel was used by the department for office purposes. The current bought from the Potomac Electric Power Co. will cost about $100 a month.

It is gratifying to learn that the project to erect a central power station by the Government which has so long met with steady opposition from certain quarters is progressing and the initial bids will soon be opened. The hydro-electric project to utilize the enormous water-power possibilities of the Potomac River in the District of Columbia does not progress. The curious might ask, "Why are these things thus?"

Correctly Designed Steam Lines skillfully erected are no more likely to fail and interrupt the service than other features, not duplicated. It is a matter of common experience that the hydraulic piping in a plant causes less trouble than the low-pressure house-service piping, because of the difference in installation. The same is applicable to steam piping.

A Sulzer Diesel Engine, built for Messrs. Harland & Wolff, for generating electricity in that firm's shop at Belfast, is said to be the largest Diesel yet constructed to a definite order. It is of the two-stroke cycle, single-acting type with six cylinders, and was designed to develop 3750 b.hp. at 142 r.p.m., though on trials 4500 b.hp., or about 750 b.hp. per cylinder, was maintained for a long period. The cylinder dimensions are approximately 30 in. bore by 40 in. stroke.—"Gas and Oil Power."

Chimneys for Oil- and Coal-Burning Plants

By F. H. Rosencrants

SYNOPSIS—Available data on chimney design relate almost solely to coal-burning plants, while little is applicable to oil burning. For given conditions a much smaller chimney is required for oil.

That a difference exists in the requirements in stack dimensions for a plant burning coal and for one burning oil is generally understood. Most available data on draft requirements and stack dimensions are applicable to coal-burning plants, so the designer of an oil-burning plant must rely upon his experience and judgment and on the meager amount of serviceable information in designing this important part of the plant. The most comprehensive treatment of stacks for oil-burning plants that the writer knows of is that written by C. R. Weymouth, presented before the American Society of Mechanical Engineers and published in bulletin form by Chas. C. Moore & Co., of San Francisco, Calif.

In a coal-burning plant it is important that the draft shall be sufficient to burn the maximum desirable amount of coal per unit of time per unit area of grate. Draft in excess of this merely provides additional overload capacity which may or may not be desirable. The objectionable feature to excessive draft in a coal-burning plant is the interest and depreciation charges for the increased cost of the stack to produce the excess of draft. However, engineers are more afraid of a deficiency than of an excess, and formulas deduced are usually liberal.

In a coal-burning plant the rate at which the boiler is steaming will demand a certain rate of combustion which requires a proportionate increase in draft. Therefore, the dampers will demand the required amount of attention from the attendant.

In an oil-burning plant the rate of steaming demands the combustion of oil at a certain rate, but this is dependent upon the position of the oil-control valve and not upon the existing draft. The boiler might be operated from no load to full load with the same damper setting, provided that setting would furnish the required amount of air for the maximum load. So at all loads below the maximum there would be an excess of air, and the smaller the load the greater the excess and consequent decrease in boiler efficiency. This condition would be accompanied by a smokeless stack and a careless or ignorant fireman might be led to think that he was running the plant economically. The trained fireman of an oil plant knows that a faint haze at the top of the stack is desirable, as that tells him that if he admits less air the stack will smoke and if more the stack will be clear and an unknown amount of excess air entering the furnace.

If the possible draft of a stack for oil burning is in excess of that required to produce the maximum desirable load, it has the double disadvantage of possible large excesses of air and of possible overloads on the boiler which might be destructive to the settings. In addition to this, there is the same disadvantage that exists with coal-burning plants, namely, the interest and depreciation charges on the cost of the excess stack capacity.

Comparative Cross-Sectional Areas of Stacks

Assuming the same velocity of the gases up the chimney for oil as for coal stacks, the former need be much smaller in cross-section than the latter for the same capacity.

Assuming an excess of air of 50 per cent., the weight of flue gases per pound of oil will be about 22 lb. Assuming a heating value of 19,000 B.t.u. per pound and a boiler efficiency of 75 per cent., the weight of flue gases per 1000 effective B.t.u. will be

$$\frac{22}{19{,}000 \times 0.75} \times 1000 = 1.544 \; lb.$$

Assuming values for coal which are attainable with the same amount of skill as those quoted for oil, we have, allowing 100 per cent. excess air, 25 lb. of flue gases per pound of coal; 12,500 B.t.u. heating value per pound; and a boiler efficiency of 70 per cent. Using these figures, the weight of gases per 1000 effective B.t.u. becomes

$$\frac{25}{12{,}500 \times 0.70} \times 1000 = 2.857 \; lb.$$

It follows from the preceding calculations that, assuming the same rate of steaming in both cases, the amount of gas which will pass up the oil-burning stack will be only $1.544 \div 2.857 = 0.541$ as much as that which passes up the coal-burning stack, therefore an oil-burning stack for a given capacity need be only about 0.54 as large in cross-section as a coal-burning stack.

Comparative Heights

It is impossible to give any hard and fast rule for the height of a coal- or oil-burning stack, as so much depends upon variable factors, such as altitude, length of breeching, character of fuel, rate of combustion, etc. However, it can be conclusively shown that in any and all cases the height of an oil-burning stack will be much less for the same set of conditions than that of one burning coal.

The draft in any case must overcome the resistance of (1) the furnace, (2) the passes of the boiler, (3) the damper box, (4) the breeching including its turns, and (5) the stack itself.

Comparing the oil-burning with the coal-burning plant with reference to the first, it is evident that the furnace resistance of the former is much less than the latter. Due to the injector action of the oil burner, the furnace resistance in the case of oil burning often is negative; i.e., the injector action of the burner produces a slight pressure. The furnace resistance when burning coal varies with the character of the fuel and the variation in thickness of fuel bed and with the rate of combustion. With average bituminous coal and a rate of combustion of 20 lb. of coal per square foot of grate per hour, the furnace resistance amounts to about one-quarter inch of water.

With reference to the second element of draft, the oil-

burning plant again has the advantage. As shown, the weight of gases for oil as compared with those for coal for the same rate of steaming is a little over one-half as much; so the velocity of the gases through the boiler is a little over one-half as great. Since the resistance to the flow of fluids varies with the square of the velocity, the boiler resistance for oil burning will be not over one-third of that for coal.

The resistance of the breeching and stack will, of course, depend upon the velocity of the gases through them, but assuming the velocity to be the same in the two cases, the resistances would also be equal, or nearly so.

It is evident from the above that the draft requirement for burning coal is in excess of that required for oil and since the draft of a stack varies with the square-root of its height, the height of a stack for burning coal is much greater than that for burning oil. It will nearly always be twice as high or more for the same rate of steaming.

It might be suggested that an oil-burning boiler could be operated at a higher rate of evaporation per square foot of heating surface than is usual for coal, since the weight of gases is so much less for the same rate. It has been found in many tests that the efficiency is improved when so operated, but the temperature produced in the furnace is destructive to the setting and this disadvantage more than offsets the slight gain in efficiency.

It would seem that, inasmuch as the factors affecting draft resistance in oil burning are so much less variable than with coal, the problem of stack design could be made exact, which is desirable.

Graphic Representations of Power-Plant Losses

By E. D. Dreyfus

SYNOPSIS—By means of a set of charts the operator is apprised directly of the approximate loss incurred, in dollars and cents, through failure to maintain the prescribed conditions.

The large central power plant usually employs a small army of operatives. Those who supervise are generally conversant with the technical requirements necessary for the highest efficiencies, but the force as a whole does not appreciate the significance of the different engineering factors involved; although from a strictly mechanical and operating viewpoint, the men may be capable and trustworthy. Taking cognizance of this, the West Penn Traction Co., of Pittsburgh, set about to devise a remedy by displaying graphically the necessity for observing conditions that have been found to produce the most efficient results. The accompanying charts show the attempts made to fasten the attention of the power-plant employee upon the enormous losses that accumulate during the year when the best working conditions are not maintained.

The object in Fig. 1 is to impress upon the firemen the importance of a high CO_2 percentage. First, it is assumed that an instrument has been installed which will give a direct reading of the CO_2 in the flue gas. Then the "burette" of the CO_2 apparatus is reproduced on the chart, with a simple scale. A standard rule is drawn opposite. with a dollar and cents scale substituted for the customary inch and fractions. The normal, or standard, percentage has been taken at 15 per cent., although a slightly lower rate may prove best in practice. Since this represents the most economical working condition, it is made to correspond to the line of zero waste, or avoidable losses. The rise of the liquid in the "burette" (imaginary, of course, while considering the chart) will be read on the "measuring stick" as indicating greater and greater unnecessary losses.

Owing to the losses in dollars and cents increasing (inversely) more rapidly than the changes in CO_2 percentage, the measurements cannot be taken on the horizontal line since plain scales are used in both cases. Hence, slanting lines are drawn to connect corresponding values.

The charts are constructed upon a simple basis. A fair estimate of the coal to be consumed during the coming year under favorable operating conditions is the foundation upon which rests all the percentages for the different operating factors. Each case is treated independently to avoid complication, although to have dealt with these factors in a cumulative manner would be the technically correct way.

Each plant must, of course, be individually considered when arriving at the percentages in any case, and the figures in the charts are merely indicative of the method.

In view of the quality of the coal and the flue temperatures, the following CO_2 percentages were determined upon:

CO_2 Percentages	Percentage Loss in Fuel	CO_2 Percentages	Percentage Loss in Fuel
15	0.000	9	7.580
14	0.808	8	9.660
13	1.750	7	13.020
12	2.840	6	16.320
11	4.130	5	21.650
10	5.690		

Coming to Fig. 2, giving the losses for operating prime movers at less than normal rated capacity (usually the economical point), it is presupposed that there are a number of units installed which may be cut in and out to conform to the load, so as to maintain a high load factor on the individual machines. Unless a separate chart is provided for each unit, a single one must necessarily be of a compromise character in view of the different sizes and types. Such a compromise curve must be employed with discretion.

Fig. 3, for feed-water temperatures, is similar to Fig. 1, but the losses have been represented by heavy black columns intended to display proportionate waste of coal, each block having its money value indicated. This variation was introduced to ascertain if the one arrangement would possess more force and effect than the other.

In condensing-turbine stations the importance of high vacuums is now fully appreciated. In this case the compromise chart of Fig. 4 was arranged. Other charts may be made if further refinements are carried out in the station.

The power-plant operator has not the same direct appeal to the personal interests of his men as is possible in

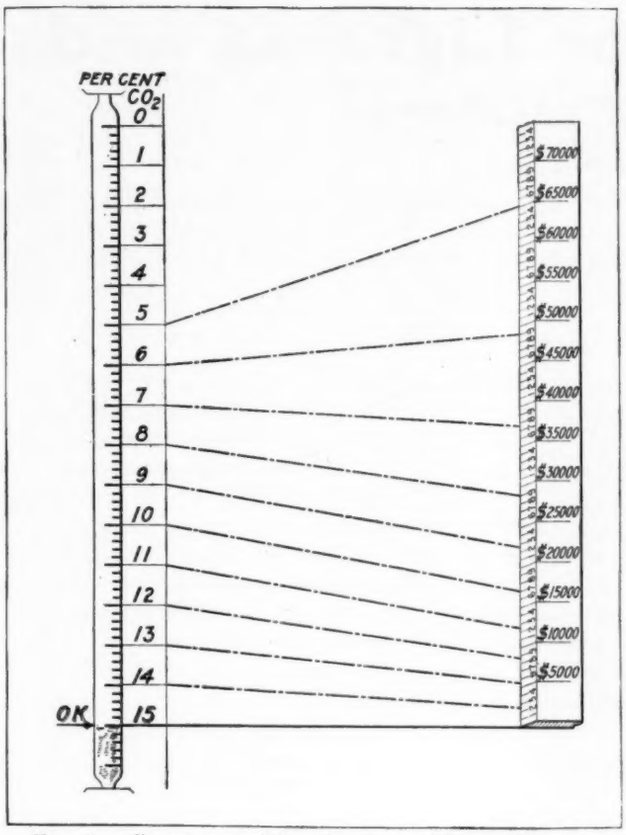


FIG. 1. CHART FOR CO_2, SHOWING MONEY LOST IN WASTED COAL THROUGH CARELESS FIRING

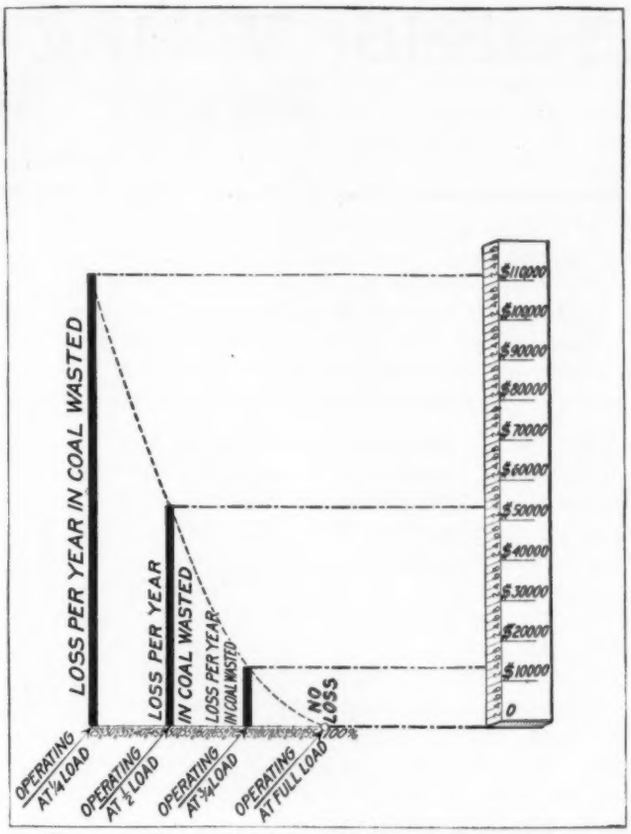


FIG. 2. CHART SHOWING MONEY LOSS DUE TO OPERATING TURBINES AT PARTIAL LOAD

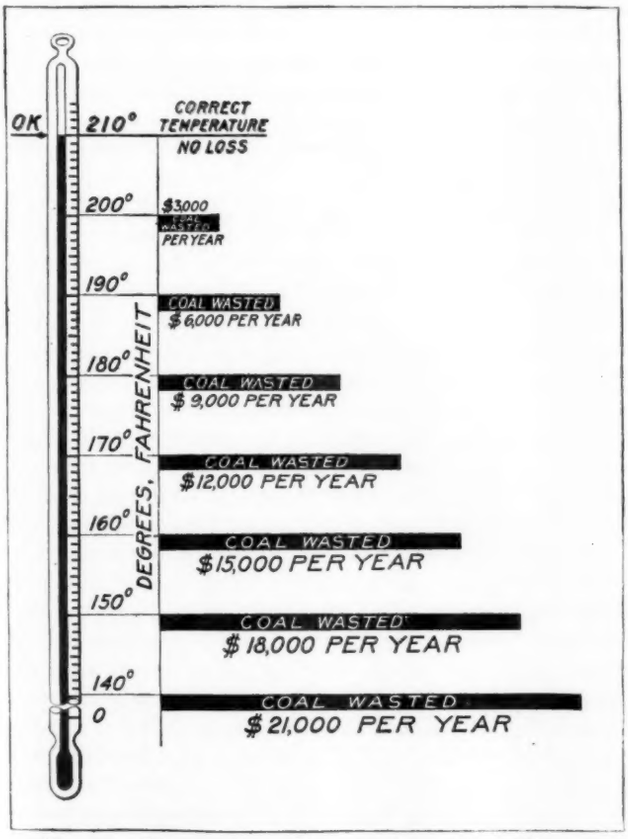


FIG. 3. MONEY LOSS DUE TO LOW FEED-WATER TEMPERATURES

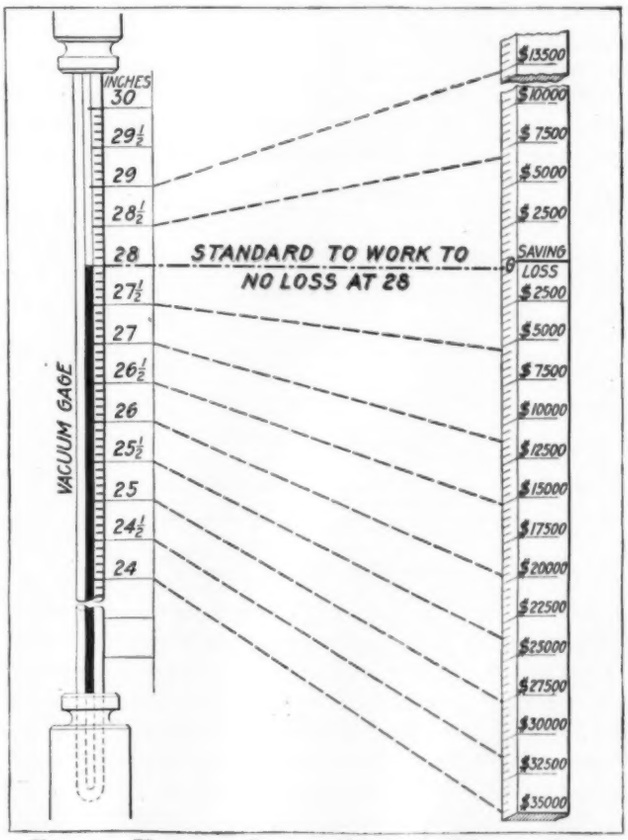


FIG. 4. VACUUM CHART, SHOWING MONEY LOSS PER YEAR FOR VARIATIONS BELOW 28 IN.

some other lines, but the security of the employee's position and, accordingly, his source of livelihood are inseparably linked with the best interest of the owner and his inherent value is gaged in proportion to what he accomplishes compared with the best practicable results obtainable within his sphere of duties.

Interior Wiring for Lighting and Power Service--II

By A. L. Cook

SYNOPSIS—Branch circuits and feeders, insulation, wire sizes, fuses, panel-boards, switches, etc. The first article of the series (May 4 issue) covered voltages and systems employed, the "National Electric Code," the types, number and spacing of lamps, and the determination of the lighting load.

When the size and location of the units have been settled the branch circuits can be arranged. The "National Electric Code" specifies that a branch circuit which is dependent upon a cutout shall not carry more than 660 watts or have more than 16 sockets and receptacles, except by special permission in cases where No. 14 wire can be carried directly into keyless sockets. Under these conditions, 1320 watts and 32 sockets may be used. The arrangement of these branch circuits should be such that the lamps on one branch are grouped as closely as possible. The lamps near the windows should be controlled separately. It is also best to so plan the branch circuits that the wires will not have to cross heavy beams or girders. Details regarding various arrangements of branch circuits will be taken up later.

Incandescent lamps are so sensitive to changes of voltage that it is necessary to maintain a steady and as nearly as possible constant voltage on them, irrespective of the load on the system. The tungsten lamp, however, is not as sensitive as a carbon lamp; for a difference of 1 per cent. in voltage the 12-volt tungsten lamp changes 3.6 per cent. in candlepower, while for a carbon lamp the change is

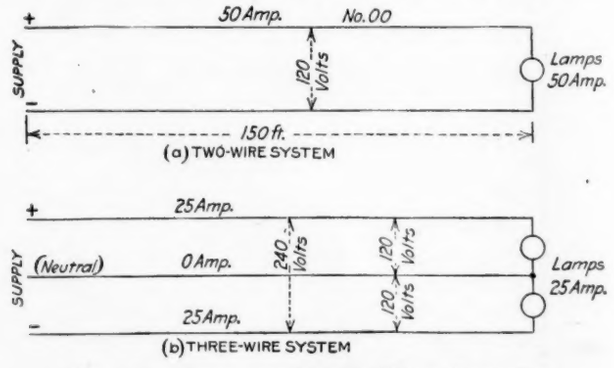


Fig. 3. Two- and Three-Wire Systems

5.6 per cent. Because of this effect, lighting circuits should not be supplied from motor circuits, but should be run independently. The voltage drop in a lighting system carrying full load should not exceed the following: Branches, 1.5 per cent.; mains, 0.7; feeders, 1.3; total, 3.5 per cent. When there are no mains, the drop allowed for the mains is included in the feeder drop.

Lamps used for indoor lighting should always be operated in multiple, as a series system with arc or incandescent lamps is not desirable, because of the high voltage necessary and lack of flexibility. Even the operation of 120- or 240-volt lamps in series on a 550-volt system is not good practice except in special cases, such as railway power houses or car barns. Because of the limitations of the incandescent lamp the lighting system must employ about 120 or 240 volts, the former being preferable.

The systems of distribution include two-wire and three-wire circuits, either direct or alternating current, and

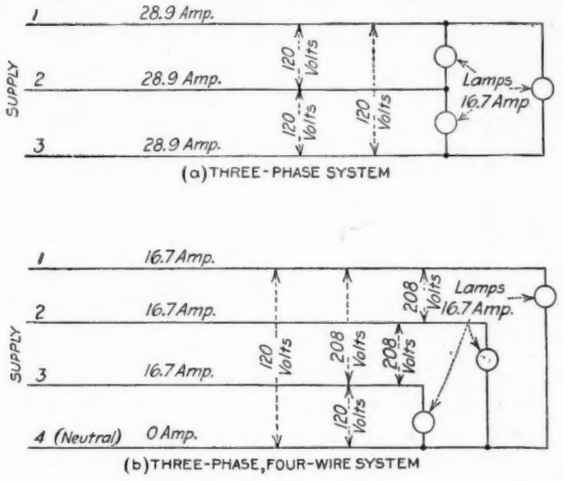


Fig. 4. Current and Voltage Relations in Three-Phase System

three-phase or two-phase. The branch circuits are generally two-wire and will be so considered in the present discussion. The feeders and mains, however, may be arranged on any of the systems mentioned. The two-wire is the simplest, but the voltage is limited to that of the lamps, which cannot exceed 240. When it is remembered that by doubling the voltage, only one-fourth as much copper is required for a given percentage drop, the advantage of using as high a voltage as possible is apparent. On the other hand, the use of 240 volts on lamp circuits increases the cost of maintenance, and the efficiency of the lamps is lower, so that 120 volts is more satisfactory. By means of the three-wire system, with 120 volts between each outside wire and the neutral and 240 between the outside wires, 120-volt lamps may be used; but the power will be transmitted at 240 volts and the copper required will be three-eighths that required for a two-wire 120-volt system. The amount of copper would, of course, be greater than if a 240-volt two-wire system were used, as this would take one-quarter of that necessary for a 120-volt two-wire system. The advantages in the use of 120-volt lamps will, however, generally justify the extra cost of the three-wire system. Fig. 3 represents a two-wire and a three-wire feeder system carrying a load of 50 amp. at 120 volts. One-half of the lamps would be connected across each side of the three-wire circuit.

The three-phase system is sometimes used for lighting, three wires being used, with the same voltage between any two; see Fig. 4. The lamps are divided equally between the three phases. Sometimes a fourth wire, called a neutral, is provided, as shown at *b*. In the arrangement shown at *a*, the copper required is three-fourths that for the two-wire system shown in Fig. 3-*a*, and in the four-wire. three-phase system the copper is one-third that necessary for the two-wire.

The two-phase system is illustrated in Fig. 5. The lamps are distributed equally across the two phases, and it will be seen that the arrangement is the same as two single-phase circuits. There is no electrical connection between the two phases, and consequently no voltage between them. The copper required is the same as for the two-wire system in Fig. 3-*a*. Frequently, two of the wires are combined, as shown at *b*. The copper required for this arrangement is 0.73 times that for the two-wire system. Further details of these systems will be taken up when the method of calculating the circuits is discussed.

Conduits

In the majority of installations rigid, unlined iron conduit is desirable, although the first cost is greater than where the wires are run exposed. The greater freedom from damage to the circuits and the improvement in the appearance of the wiring will generally justify its use. In factory wiring, it is sometimes better to run the feeders exposed, using iron conduits for the mains and branches, particularly in an extensive plant where the feeders can be so located that they are not likely to suffer damage. The conduits must be large enough to allow the wires to be pulled in after the conduits are in place without damaging the insulation. The size depends, therefore, upon the number of bends. The "Code" requires that the maximum number of bends shall not exceed the equivalent of four right-angle bends, and if more are necessary a pull-box must be inserted in the run so that the wire may be pulled in sections. It is desirable to make the radius of the bends as great as is consistent with other limitations. The stock bends, which can be purchased from the conduit manufacturers, can be used, except in special cases, where a longer-radius bend is desirable. The ordinary iron conduit consists of soft-steel pipe made

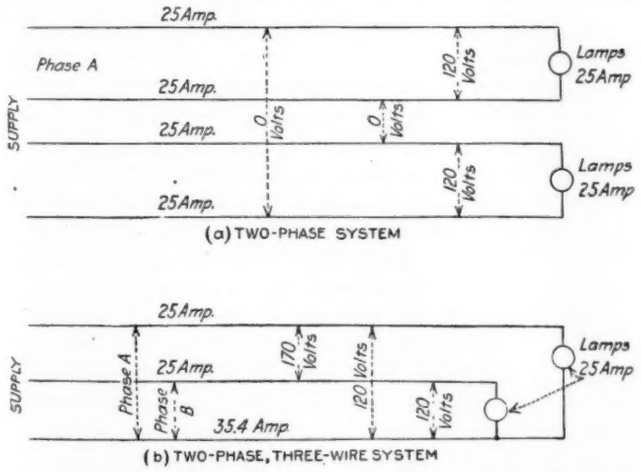


Fig. 5. Current and Voltage Relations in Two-Phase System

in standard-weight iron-pipe sizes and threaded the same. It has a heavy, smooth coating of enamel on the inside to facilitate pulling in the wire and is either enameled or galvanized on the outside. The galvanized conduit is more desirable where it is to be painted after installation, and it can also be more easily grounded as required by the "Code."

In Table 6 are given conduit sizes for various sizes of wires, covering most of the conditions met in practice and suitable for fairly long runs. For longer runs, if the number of bends is decreased, the same sizes may be used; for shorter runs, the size may in some cases be reduced. An approximate rule is to choose such a size that the wires will just be contained inside a circle three-quarters the outside diameter of the conduit. For alternating-current work all the wires of a circuit must be contained in the same conduit. This is required by the "Code," because if run in separate iron conduits there would be excessive

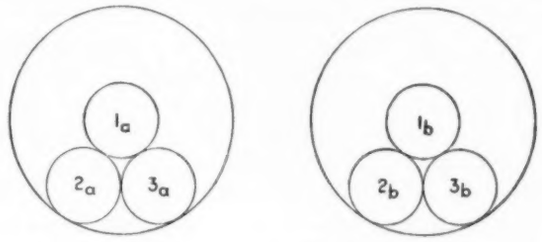


Fig. 6. Illustrating Wires in Conduit

heating of the conduits and a greatly increased drop due to the alternating magnetic field produced by the current flowing in the wire. This effect will be greater the larger the current, but even for the smallest wires the rule should be followed. If the conduits are of brass, fiber or tile, the wires can be safely separated in different ones, but even then the drop is so great that it is generally better to combine the circuit in one conduit. If the current is so great as to require more than one wire for each lead of the circuit, and it is not feasible to put them all in one conduit, the leads should be divided into two or more groups, each containing all the poles of the circuit. The proper arrangement for a three-phase circuit is shown in Fig. 6, where the leads of the three phases are 1, 2 and 3 respectively, 1-*a* and 1-*b* being of the same polarity. This rule applies for all types of alternating-current systems except the two-phase four-wire, which is practically the same as two single-phase circuits, and phases *A* and *B* may be run in separate conduits. For direct-current circuits it is satisfactory to employ separate conduits for each wire, if of large size, unless there is probability of a change being made to alternating current.

TABLE 6—SIZES OF UNLINED IRON CONDUIT FOR 600 VOLT N. E. C. STANDARD RUBBER WIRES

Size of Wire	Number of Wires in One Conduit—One	Two	Three	Four
14*	½ in.	½ in.	¾ in.	¾ in.
12*	½ in.	¾ in.	¾ in.	¾ in.
10*	½ in.	¾ in.	1 in.	1 in.
8	½ in.	1 in.	1 in.	1 in.
6	¾ in.	1 in.	1¼ in.	1¼ in.
5	¾ in.	1¼ in.	1¼ in.	1¼ in.
4	¾ in.	1¼ in.	1¼ in.	1½ in.
3	¾ in.	1¼ in.	1¼ in.	1½ in.
2	¾ in.	1½ in.	1½ in.	2 in.
1	¾ in.	1½ in.	2 in.	2 in.
0	1 in.	2 in.	2 in.	2 in.
00	1 in.	2 in.	2 in.	2½ in.
000	1¼ in.	2 in.	2½ in.	2½ in.
0000	1¼ in.	2 in.	2½ in.	2½ in.
300,000	1½ in.	2½ in.	3 in.	3 in.
400,000	1½ in.	3 in.	3½ in.	3½ in.
500,000	2 in.	3 in.	3½ in.	3½ in.
600,000	2 in.	3½ in.	4 in.	.....
700,000	2 in.	3½ in.	4 in.	.....
800,000	2 in.	3½ in.	4 in.	.....
900,000	2½ in.	4 in.	4½ in.	.....
1,000,000	2½ in.	4 in.	4½ in.	.....
1,250,000	2½ in.	.....	.....	.....
1,500,000	3 in.	.....	.....	.....
1,750,000	3 in.	.....	.....	.....
2,000,000	3 in.	.....	.....	.....
14 duplex*	.....	½ in.	.....	.....
12 duplex*	.....	½ in.	.....	.....
10 duplex*	.....	¾ in.	.....	.....

Based on runs not over 100 ft. long and not over four standard bends.

*These sizes are solid; all other sizes are stranded.

Exposed wiring may be run on porcelain cleats, or insulators, the spacing being as follows:

Voltage	Distance from Surface	Distance between Wires
0—300	½ in.	2½ in.
301—550	1 in	4 in.

For wires not less than No. 8 B. & S. gage in locations where they will not be disturbed, the spacing may be made 6 in. and the wires run from beam to beam, without breaking around. By this means, feeders and mains may be run in a direct line the entire length of a building and supported by the beams or roof trusses. This results in minimum cost and makes a very satisfactory arrangement.

Insulation

Wire for interior work may have two kinds of insulation—rubber or weatherproof—depending upon the method of running the wires. Rubber wire must be used if installed in conduit, but for exposed or so-called cleat wiring, a cheaper insulation is allowed. The rubber insulation used in most installations is called "Code" wire and is manufactured in accordance with very rigid rules contained in the "National Electric Code." Every coil must bear the stamp of the inspection department of the Board of Fire Underwriters, so there is no difficulty in identifying such wire. Sometimes, for important installations, a quality of rubber insulation which is better than "Code" wire is used, and its greater cost is often justified by the resulting reduction in breakdowns on the system. Public buildings, railway stations, office buildings, and sometimes industrial plants can afford to use this better quality for greater insurance against interruptions to the service. No insulation poorer than "Code" wire should ever be used, even if the work is not inspected by insurance representatives.

The insulation used for exposed work consists of two braided-cotton coverings over the copper conductor, the inside covering being impregnated with a weatherproof compound, and the outside one filled with a fireproof compound. This is called "slow-burning weatherproof" wire. Sometimes another type, called "slow-burning," is used, this being similar to the other except that the entire insulation is fireproof. This is satisfactory for dry places where the wires are run exposed on insulators.

In Table 7 are given the safe carrying capacities for various sizes of wire used for interior work as specified in the "National Electric Code." Column A gives values for rubber and column B for "slow-burning weatherproof" and for "slow-burning." It will be noticed that for rubber wire the current allowed is less than for the other insulation, because it is necessary to keep the rubber-covered wires at a lower temperature to prevent damage to the insulation. The currents specified for rubber insulation will cause the wire to run at about 29 deg. F. above the surrounding air.

The "Code" makes no distinction in carrying capacity between alternating and direct current. For alternating currents, especially at 60 cycles, there is a greater drop, particularly for large wires. Even with 500,000-circ.mil cables, the resistance is 2½ per cent. greater and for 1,000,000 circ.mil it is about 11 per cent. greater. This would result in the wires running somewhat hotter when carrying alternating current.

Fuses and Circuit-Breakers

All wiring must be protected by fuses or circuit-breakers in such a manner that the circuit will be opened if the rated current is exceeded. The size of the fuse must not exceed the carrying capacity of wire as given in Table 7. For example, a No. 1 wire, if rubber covered, would be protected by a 100-amp. fuse, and if "slow-burning weatherproof," would have a 150-amp. fuse. When circuit-breakers are employed without fuses, they must not be set more than 30 per cent. above the rating of the wire as given in the table. The excess current which the fuses will carry continuously is about 10 per cent. for inclosed and 25 per cent. for link fuses, which allows small overloads without interrupting the service. The rating in Table 7 is based only on the safe current-carrying capacity of the wires, and should not be exceeded; but it takes no account of the drop in the wires. In many cases, the length of the run is so great that the drop with the rated current would be excessive, in which event a larger wire must be used.

TABLE 7—CURRENT-CARRYING CAPACITY OF WIRES FOR 600-VOLT INSULATION, N. E. C. STANDARD FOR INTERIOR WIRING

Size, Circ. Mils	Size, B. & S. Gage	Rubber Insulation, Amperes A	Other Insulations, Amperes B
1,624	18*	3	5
2,583	16*	6	10
4,107	14	15	20
6,530	12	20	25
10,380	10	25	30
16,510	8	35	50
26,250	6	50	70
33,100	5	55	80
41,740	4	70	90
52,630	3	80	100
66,370	2	90	125
83,690	1	100	150
105,500	0	125	200
133,100	00	150	225
167,800	000	175	275
211,600	0000	225	325
300,000		275	400
400,000		325	500
500,000		400	600
600,000		450	680
700,000		500	760
800,000		550	840
900,000		600	920
1,000,000		650	1000
1,100,000		690	1080
1,200,000		730	1150
1,300,000		770	1220
1,400,000		810	1290
1,500,000		850	1360
1,600,000		890	1430
1,700,000		930	1490
1,800,000		970	1550
1,900,000		1010	1610
2,000,000		1050	1670

Note—Voltage drop is not considered in the above table.

*Wires smaller than No. 14 B. & S. gage should not be used except for fixture wiring and pendant cords.

In lighting installations of any considerable size, there will be a large number of branch circuits, each provided with the proper fuses. For convenience these are grouped, as far as possible, in a panel-board, containing the necessary branch fuses and in some cases the control switches. For industrial plants, slate panel-boards contained in steel cabinets with steel doors are the most satisfactory. For office buildings, etc., slate panel-boards with steel cabinets set flush with the surface of the wall are generally required. The doors are preferably made of wood to match the trim of the building, although steel doors are sometimes used. While economy demands as few panel-boards as possible, a single board should not contain more than 30 branch circuits. If more must be supplied from the same point, it is better to use a double panel-board with two sets of busbars and two doors. Each branch should contain fuses for protecting the circuit and in many cases a branch switch is also provided. These switches should be placed next the busbars, so that when open, the branch circuit fuses may be replaced without danger of short-circuit or shock. Branch circuit switches are not really necessary, except when used to control the branch circuits. In many industrial establishments, it is best to keep the panel-boards locked and provide switches outside for controlling the lights. This arrangement should also be used in office buildings. For public buildings, such as railway stations, most of the lights are controlled directly from the panel-board switches and in many factories this is

done to save the cost of additional switches. The feeders supplying the branch circuits must be run to some central point of supply such as panels on the switchboard. If central-station service is used, it is best to install a regular switchboard except when the number of feeders is small, in which case a panel-board can be used. In every case, a suitable switch disconnecting every wire of a feeder should be provided for each circuit. The largest size of fuse allowed by the "Code" is 600 amp. for voltages up to 250 and 400 amp. for 600-volt circuits. Circuits requiring more current than this have to be protected by circuit-breakers. Lighting circuits are not subject to large overloads, so that the fuses should not blow unless there is a short-circuit. If circuit-breakers are used in place of fuses and are arranged to automatically trip out when closed on an overload, the switch may be omitted. Fuses or circuit-breakers should be large enough to give the full carrying capacity of the wires, in accordance with Table 7, even if the actual load on the feeders is considerably less.

Wiring Accessories

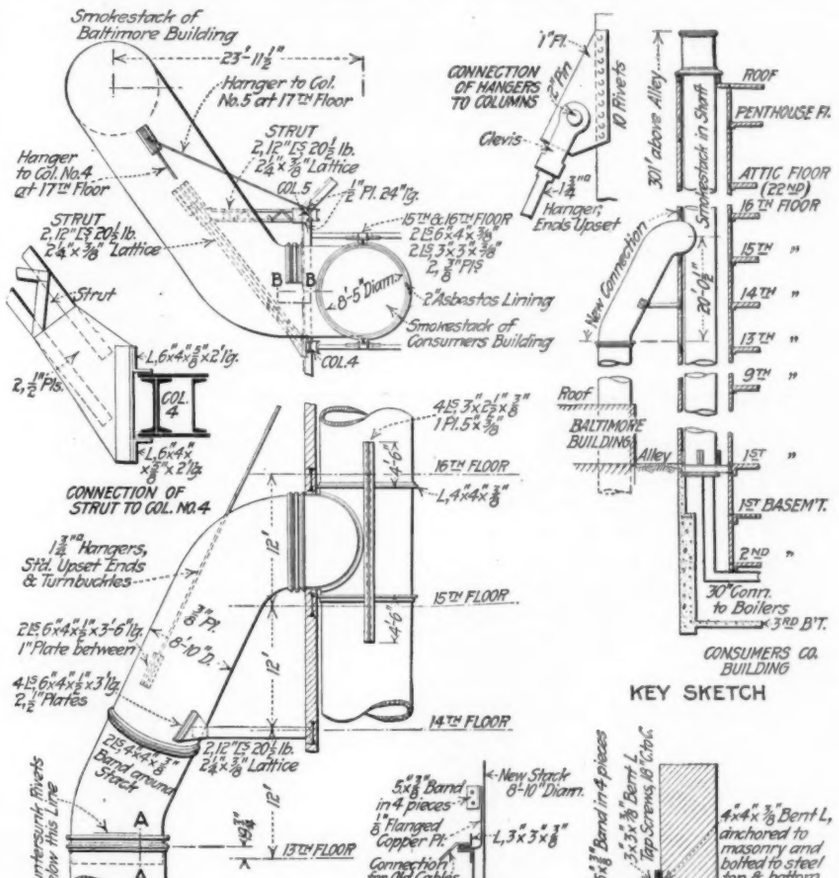
A detailed discussion of the wiring fittings, such as sockets, switches, outlet boxes, and the like, does not properly belong in this article, but a few suggestions may be of value. For exposed conduit work, complete lines of devices such as condulets have been developed to meet almost any requirement, and their use assists greatly in making neat work. For ceiling outlets, where there is no danger of the lamps' being hit, a "T" fitting may be conveniently used, the drop to the lamp consisting of a piece of half-inch conduit. Enameled reflectors are provided complete with sockets, which can be attached directly to this pipe. Glass reflectors require the use of an ordinary keyless socket with a suitable shade holder. Tungsten lamps will operate satisfactorily in this type of fixture, unless there is excessive vibration, in which case it may be necessary to use flexible cord for the drop. For concealed rigid conduit work, the outlets are provided with pressed-steel boxes, which should be galvanized rather than japanned, to assist in grounding the conduit system. Control switches outside the panel-boards may be either of the rotary or push-button variety; the latter is better for offices and the rotary switch, which is somewhat cheaper, is satisfactory for industrial establishments. Nothing smaller than a 10-amp. switch should be used, for the sake of mechanical strength.

Conductivity and Resistance are relative terms. It is customary to divide all material into three groups depending on their relative conductivity: First, metals and their alloys are good conductors; second, electrolytes, so called because they may be decomposed by passing electric current through them, are poor conductors; third, resistance, bad conductors or good insulators consist of such well-known materials as rubber, glass, ebonite, shellac, mica, etc.

Complicated Smoke-Stack Connection

The new 22-story Consumers' Building, State and Quincy St., Chicago, has an 8½-ft. asbestos-lined steel stack in a shaft at the rear of the building. This stack, 301 ft. high above the street, was originally intended to serve a heating plant in the building, but later service was secured from a plant in the Baltimore Building, an older eight-story structure at the rear.

In the basement of the Baltimore Building is one of the heating plants of the Illinois Maintenance Co., which supplies steam for heating throughout the block and also for the Fair, a large building occupying the adjacent



Connection between an Outside Smoke-Stack and an Inside Smoke-Stack at Two Adjacent Buildings in Chicago

block. The smoke flue from this plant extends in the building only to the third floor, where a connection is made to an unlined outside steel stack supported on cantilever brackets. It was realized that with this large power plant it would be impossible to control the smoke to such an extent that it would not be obnoxious to tenants in the higher adjacent Consumers' Building, while it would soon blacken the white glazed terra-cotta facing of the rear of that building. In order to forestall these difficulties the Illinois Maintenance Co. made arrangements to connect its outside stack on the Baltimore Building with the inside stack of the Consumers' Building.

The arrangement and the details are shown in the illustration. As the two stacks are not in line the connection is inclined from north to south as well as from east

to west. A special feature of the construction is that the connection (which weighs about 14 tons and extends across the alley) is supported from the framing of the Consumers' Building, so that no part of its weight is carried upon the lower stack. The bottom of the connection simply telescopes into the latter stack, a flashing being arranged in the joint. This allows free expansion and contraction of the stack, while in case of fire and the fall of the walls of the Baltimore Building (a nonfireproof structure) the stack would drop away without affecting the Consumers' Building.

The connection between the two stacks is a shell 8 ft. 10 in. diameter, with an elbow at each end. The bottom elbow enters the top of the shorter stack, and the upper elbow connects to the side of the stack in the Consumers' Building. The weight is carried by 1¾-in. hangers with 2-in. pin attachments to brackets on the stack connection and pin plates on the columns of the building, as shown in Fig. 2. The lateral thrust is taken by a pair of horizontal box-lattice struts bearing against the columns of the building at the level of the 14th floor.

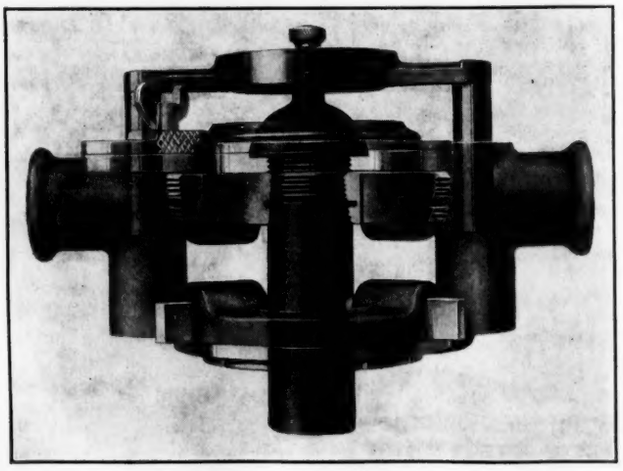
The design for this stack connection was made by Mundie & Jensen, of Chicago, architects for the Consumers' Co. Building. The steelwork was built and erected by the Hansell-Elcock Co., also of Chicago.—*Engineering News.*

Beaver Crossbar Die Stock

The Beaver crossbar die stock, manufactured by the Borden Co., Warren, Ohio, differs from other die stocks in several important features.

A bar extends across the top of the tool, carrying a plug which rests on the end of the pipe. The dies are made in two sections. The lower one does the rough work of starting on the pipe with teeth especially formed for this purpose. The die remains stationary during starting and after the upper section begins to cut this lower die gradually withdraws from the pipe, until it no longer touches, as shown in the illustration.

The upper die is a narrow receding die and constantly opens as the thread is cut, producing a perfect standard



Beaver Crosshead Die Stock

pipe thread. These dies have the further advantage of following the partial threads cut by the first section, which reduces the labor and insures a correct thread pitch without a leader screw.

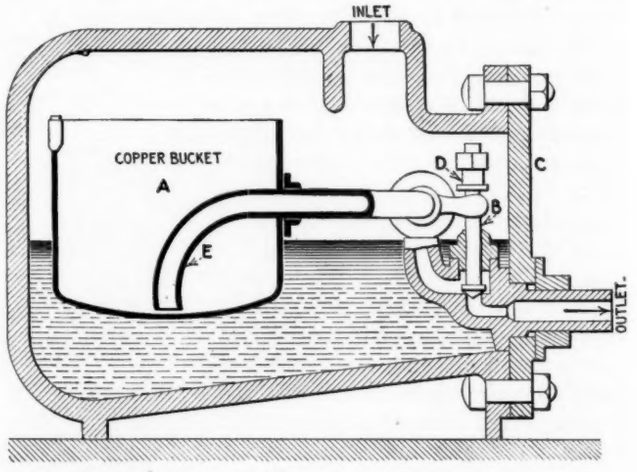
The principle involved is as follows: A swiveled plug extends down between the dies to the bottom of the upper section in starting. The pipe is started and threaded as usual. When the work of the lower stationary die is completed the pipe end comes in contact with the swiveled plug, raising it as the second set of dies cut the thread. Raising the plug lifts the side posts, turns the engaged die cam, and gradually opens the dies at the pipe taper until the thread is completed, when the dies are released; there is no backing off.

The operation of the tool is simple. The dies are set by the handle shown, and the pipe is threaded without the attention of the operator. To cut another thread the crossbar is simply pushed down, which re-positions the tool. The body of the tool is made of practically one piece with wide openings to allow chips to get away and for free oiling facilities.

A universal guide centers all sizes ¼- to 1¼-in. The tool is regularly furnished with double-ended, reversible dies ½- to 1¼-in. Extra ¼- by ⅜-in dies can be furnished, also all sizes of dies, either right- or left-hand.

Dinkel Steam Trap

The Dinkel steam trap, illustrated herewith, employs an open, copper-float bucket *A*, a valve *B* and connections, all of which are inside the trap chamber. The valve is held closed by its own weight and the pressure



Section through the Dinkel Steam Trap

within the trap chamber, and is opened by an increased pressure exerted upon it by the action of the float. As the working parts are attached to the end plate *C*, they are easily removed.

As water fills the trap chamber it raises the float until it strikes against the top of the chamber. As it can go no further the water continues to rise and overflows into the bucket, which, when full, sinks to the bottom of the chamber. This action brings the projection of the lever arm against the thimble *D* on the top of the valve stem and lifts the valve from its seat. The water in the bucket and that above the top of the bucket is then discharged through the connection *E* and through the valve. When the discharge ceases the bucket rises until it floats and the valve closes.

A body of water is always left above the valve seat after each discharge, which prevents the escape of steam.

This trap is manufactured by the Flushovalve Co., 536-538 Broome St., New York City.

Editorials

Government Fuel-Test Reports

The coal that produces the largest net returns per dollar invested is the coal to burn. If the right kind of furnace is not under the boilers to burn the coal used, it is good business to put in that furnace and make all other necessary changes.

All of the various grades of coal mined in the United States must be and will be burned in some way or other, and it is the engineer's part to burn it with the greatest economy, both for the sake of the owner and for coming generations.

To burn coal with maximum efficiency, exhaustive tests have been and are being made by competent engineers under United States Government supervision. By studying their reports one can decide with certainty on the kind of grate and setting to install. To make such tests oneself would be out of the question, because of the expense. Government reports should be studied.

It Is the Little Things

"It is the small details which go toward making perfection; and this last is no small thing." An artist said this when asked why he was taking such care in the representation of a familiar object forming but a minor portion of the work under his hand. What he replied is a truism, something we are inclined to admit in the abstract and prone to forget in the concrete. Perfection, one-hundred per cent. efficiency, is the unattainable; yet that should not and does not usually prevent striving for that goal. But what is it that stands in the way, barring the attainment of perfection? Just a little thing, the small fractions of that last one per cent. between the attainable ninety-nine and the unattainable one-hundred. Small and insignificant in themselves, those figures that represent the gap are the wondrous monument that marks the progress of the world, of science, of engineering, of chemistry. They are the fruit of the toil and the study of the ages. Looking back upon the methods of a few years ago with the searchlight of today, it is difficult to remember that, in their time, those methods formed the apex, that those who strove to surpass them were pioneering in the same way as those who now strive to pass the mark.

Today, as yesterday, all of the works of the world are but aggregations of the small details, their components; and none of them is without significance. And as the great work stands as the monument of its builder, so does each of its components. Each small detail as it lacks perfection contributes to the imperfection of the aggregate, and still more will it detract if, inherently imperfect, its functions have not been properly coördinated with the other components. Just as the weakest link governs the strength of the chain, so is the validity of any structure dependent upon its weakest component. In itself of little account and of small moment, when located at a strategic center it becomes the keystone of the arch. If it fails, then the deluge and the storm, the wreck; and then, sometimes, rebuilding.

All the lessons of the ages are bound up in a few words, easy to remember, easy to forget. But to those who can read their story it is written in letters of flame, "Forget you not of the details, nor of the end thou wouldst attain."

Examination

The safety of life and property demands that only careful, experienced men shall be allowed to operate steam plants.

The temptation to hire cheap help or to give a deserving friend a job is too much for many employers. They welcome an excuse which enables them to send the importuning candidate to some disinterested board or commission, with instructions to get a license or to get placed on a civil-service list.

But how is this disinterested board to find out if the man is qualified?

Most such boards have members who are educated, in the common sense of the word—that is, they have been to school. An examination to them means a written test in which all the candidates are asked a given set of questions on which they are marked like so many school children.

If they stopped to think, they would realize that it is nearly impossible to get up a single examination that will tell a true story of the candidate's fitness. When it is necessary to offer examinations every few weeks, each of which must be different from those which have preceded it, the problem becomes wholly impossible of solution along these lines. The result is that a few questions are thinly disguised and made to answer for a series of examinations. Shrewd men can pick out the few questions and see through the disguises, and armed with the knowledge that there will be little variation, they coach men who are normally unfit, so that they can get licenses. Likewise, it is just as necessary for the men who are fit to take this same coaching in order to pass, for the questions of necessity have little connection with the everyday practice of their trade.

How the essential qualities that make a successful engineer can be truly judged except on the job has always been more or less of a puzzle to us. What a man will write as an answer to a question dealing with a blown-out tube, and what the man will do when confronted with the actual accident, are two different things. It is very much like training soldiers by giving them written examinations. Instead of that, they are drilled until their work becomes automatic and their officers know that as a matter of habit they will obey orders and obey them in the same way every time.

Just so an engineer should be trained so that if he hears the sound of escaping steam in any direction he will unconsciously do the right thing, and do it at once. It is better for him if he understands the reason why and does it intelligently, but as a matter of safety the

important thing is that he shall do it without stopping to think.

The question of the competence of the man to produce the maximum amount of service from the minimum of coal is also something that can be told only on the job, and in which he can be trained only on the job. No amount of questioning, nor even of preparation for examination, will add to the power produced per pound of coal, nor will it give much of a line on what the man will do once he gets on the job.

We suggest to the various legislatures which are annually struggling with this problem, that they investigate the means of training engineers in safety and efficiency and then fit their laws to what is possible.

Safeguarding the Bus Room

Close scrutiny of the arrangement of busbar compartments in a number of power stations indicates the desirability of paying more attention to safety features in laying out and operating this important part of the plant. In high-tension installations adequate space is generally conceded to busbar and oil-switch equipment, for the two are closely related and there is economy in copper where short and symmetrical connections are possible between disconnecting devices and busbar sections. It is the good mechanical job that best serves the needs of a high-tension gallery or switch room, and straight, simple runs of wire or copper tubing, combined with what might be called a clean-cut switching arrangement without complications in its apparent relations to the circuits, generating units, transformers and busbars, make one of the best possible designs.

In lower-voltage work it is not uncommon to find the space assigned to switches and busbars cramped in the extreme. Week after week these portions of the equipment stand the demands of service without a "hitch," and then, without an instant's warning, a heavy short-circuit on the distribution system or possibly on some interstation tie line, backed up by the generating capabilities of perhaps half a dozen units, transforms these compartments into a spectacular sample of the lower regions. The manner in which arcs backed by ample generating capacity will at times communicate to neighboring switch cells, accompanied by the carbonization of cable insulation, need not be detailed here, but the initiated appreciate the wisdom of allowing plenty of space in passages around such compartments and of using barriers of substantial thickness in providing accommodations for this sort of equipment. To the casual visitor to a plant the allotment of liberal space to busbar and switch mechanism housed in by concrete or other barrier construction appears almost needless, but when operating emergencies occur plenty of elbow room is invaluable.

Too little attention has been paid in many plants to the lighting of such rooms by **permanently** installed lamps wired in conduit and **controlled from** outside the room itself, and often, where permanent lamps are used, the sizes are too small for throwing the necessary light into recesses of cells. Moreover, it is petty economy to install a low-powered unit without a suitable reflector in this part of a station. Switch mechanism is almost always painted black with asphaltic compound, and the point is worth looking into whether it would not pay in some cases to use white enamel paint or a judicious combination of the two, in order to make the adjustable parts and points of lubrication stand out more prominently.

In stations where two or more men are on duty per shift it would not be a bad plan to provide outside the bus room a pilot lamp which will show the presence of anyone within, and in not a few stations too little care is taken in admitting visitors to this part of the building. If there is any place in a station outside the main operating and boiler rooms where first-class lighting, ample space, local telephone service and dual means of exit are desirable, it is the bus room.

The Noise Question

Present-day engineers, machinists and others who work in the midst of noise seem to regard it as a necessary evil. Pump operators who are working beside noisy, nerve-racking metal gears—so clamorous that it is impossible for them to hear spoken words without having them shouted into their ears—should look about for means to reduce the din. These noises can be lessened if not totally eliminated.

It has been demonstrated repeatedly that when harassed by noise the average man cannot concentrate on his work as well as he can in quiet surroundings. Then why not make shop and plant conditions favorable to maximum work and production by cutting out all unnecessary noises?

It is difficult to make workers in offices consider this problem, because there is comparatively little noise in an office. Office men who once worked in noisy places should appreciate the difference and be keen to take advantage of every possible point helpful to the highest economy and maximum production, and at the same time if they wish to do a good turn for humanity they will do all in their power to promote quietness for their subordinates who are now compelled to put up with disagreeable surroundings.

Quietness is a factor of efficiency that is too frequently completely overlooked.

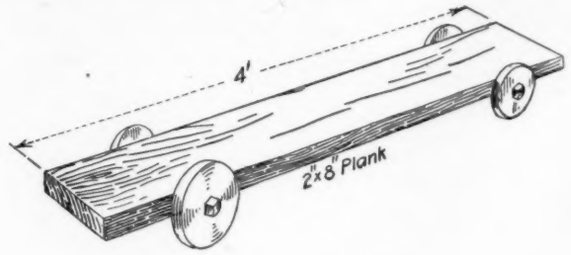
One of the greatest benefits of classroom lecture or lodgeroom study, as against self-education by solitary study, is the spoken word when correctly spoken. In classroom recitation or discussion the free and familiar use of terms becomes a habit, while in study at home the utterance of the same terms may be only at rare intervals if at all. Should occasion arise for comparison, which will "show up" to the best advantage, granting an equal knowledge of the subject matter? Unless words and terms are used with assurance they cannot carry the weight of conviction and will, therefore, serve to defeat the object of their use. A splendid exercise for the lodgeroom is the use of a good pronouncing dictionary, every fellow to take a turn at the definition and pronunciation of words and engineering terms more or less commonly used. Many perfectly good words will go lame and be so disguised by improper accent as to be hardly recognizable.

The prompt adoption by the Ohio Board of Boiler Rules of the Code of Specifications for the design, construction and operation of steam boilers and other pressure vessels is very gratifying. It is hardly believable that either inertia or opposition can long prevent its universal enforcement.

Correspondence

A Handy Car for Inside of Boiler

The illustration shows a handy device for the boiler cleaner or inspector. We used a 2x8-in. oak plank 4 ft. long and beveled the ends on the under side. The wheels used were old worn-out valve disks from a feed



Boiler Cleaner's Car

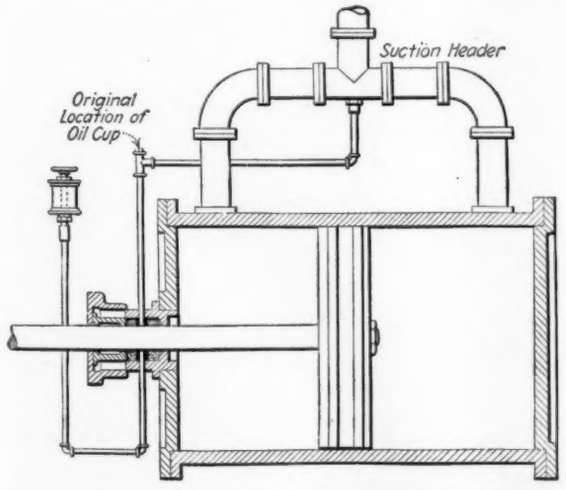
pump put on with lagscrews about 6 in. from the end, as shown. In this way we have a car that can be propelled to the back end of a boiler in a jiffy and we can come out dry.

A. C. Chrisman.

Girard, Ill.

Lubricating Compressor Piston Rod

The stuffing-boxes on two ice machines in a small refrigerating plant gave considerable trouble. Unless three or four times as much oil as is usually needed was supplied, the rods would either run hot or leak and the packing would soon wear out. It was difficult to keep engineers for a time after the plant was started, and most of them kept out of trouble with the ammonia rods by using excessive quantities of oil.



Lubricating Ammonia-Compressor Piston Rod

Finally, a man came along that stuck to the job. As soon as he was settled he turned his attention to the ammonia rods. The oil-cup connections to the stuffing-boxes struck him as peculiar and not according to the best practice, so he decided to change them.

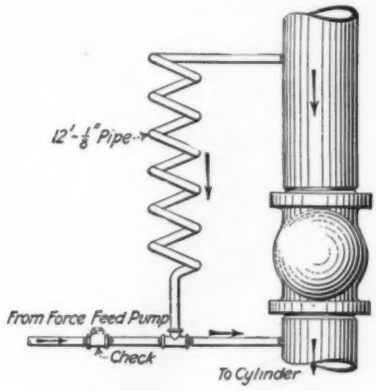
The sketch shows the oil cup in the changed position and also shows its original location. The machines were of the horizontal double-acting type. In this machine there is usually more or less gas escaping through the connection to the suction line. With the original connection the escaping gas carried much of the oil along with it into the suction line and into the system; in fact, the system was loaded with oil, as was found later. Connecting the oil cups to the under side of the stuffing-box overcame this defect and thereafter a small amount of oil was needed.

Thomas G. Thurston.

Chicago, Ill.

Condensing Coil on Oil Feed

At the request of an oil salesman we experimented with a ⅛-in. copper coil 12 ft. long in connection with the force-feed lubricator, the object being to break up the oil by the addition of a little moisture. The steam pressure carried was 140 lb. gage, superheated to about 440 deg. F.



Condensing Coil as Connected

The result was so surprising that we think it will interest the readers of Power. With the same amount of oil formerly used the valves appeared to stick. Doubling the quantity of oil took care of that trouble, but the piston became noisy and developed a decided pound at each end after a 12-hr. run, and it was decided the steam-ring springs were too stiff. New springs were put in, but this did not stop the noise.

An examination 12 hours later proved the lubrication was deficient, and there was no vestige left of a glaze on the cylinder wall of six years' standing. The oil atomizer was removed, and the engine again operated with the original amount of oil with the most gratifying results. The question is, what effect does the superheat (80 to 100 deg. F.) have on an emulsion of cylinder oil and water? The oil is a standard high-grade article made

from Pennsylvania crude and for superheated steam. The object of the condenser coil was to cut down the amount of oil used or to substitute a lower grade.

C. H. Reed.

East Chicago, Ind.

Metallic Packing for Valve Stems

About a year ago it became necessary to renew the metallic packing on the Corliss type valve stems of a large pumping engine. To get a tight job with such packing it

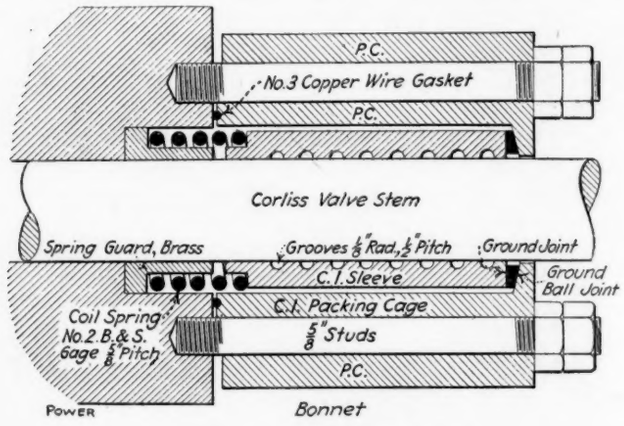


Fig. 1. With Packing Case

is necessary to take great care in truing and grinding the rings and ball washers, and the job is expensive. The superintendent objected and said: "We want something we can make ourselves; it is up to you to dope out a design that is simple, steam-tight and cheap." My first attempt is shown in Fig. 1. I don't pretend to be able to say what happens in the grooves and nozzles, but the steam is so busy chasing itself in and out of the grooves that little finds its way to the end of the sleeve.

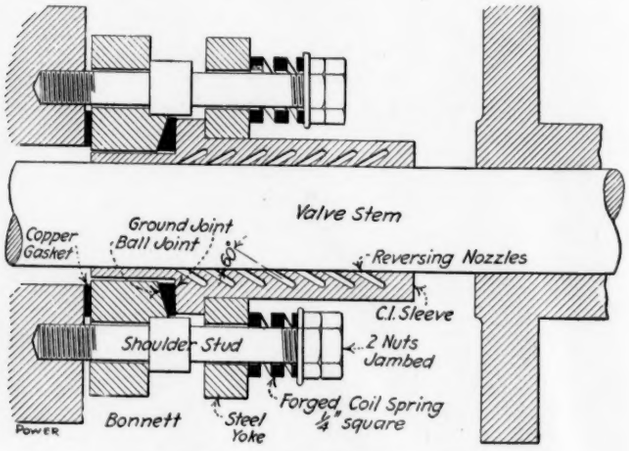


Fig. 2. Modified Form

Fig. 1 is on the exhaust valve stem of a high-pressure cylinder working steam at 200 lb. pressure. It was put in on Feb. 10, 1914, and has run 24 hours every day since and is practically steam-tight.

Fig. 2 does away with the packing case and need not fit the stem so closely. It is best for stems that do not run true. Fig. 3 is now used on the low-pressure exhaust valve stems and is sealed with steam from the low-pressure receiver at 6 lb. gage through the pipe shown, or in other cases this may be used as a drain pipe.

For all other stems the nozzles all point toward the

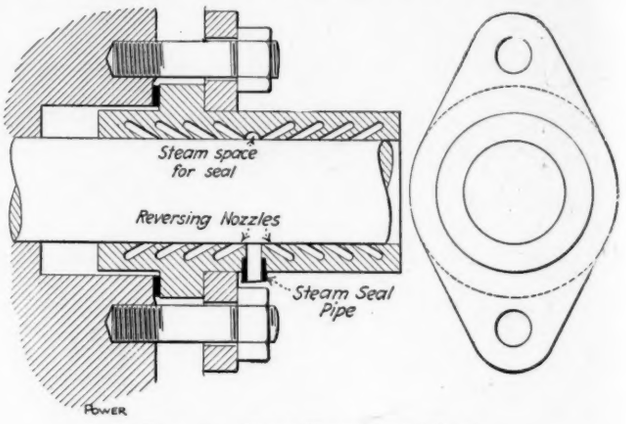


Fig. 3. Low-Pressure Type

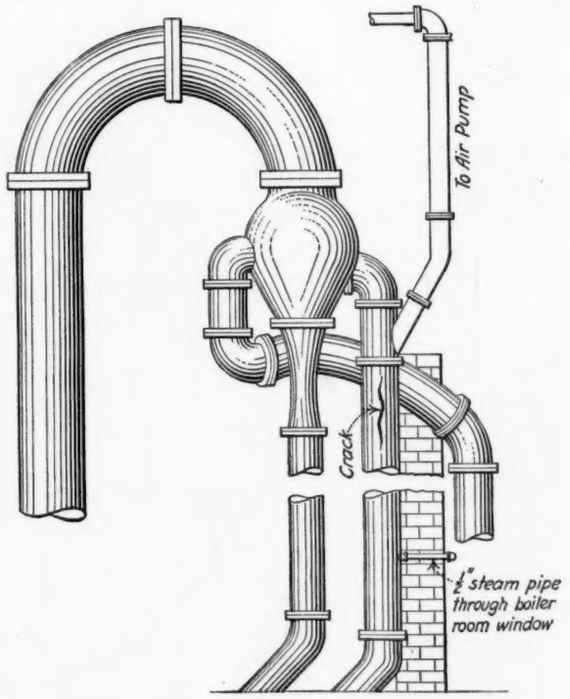
valve. If anyone is interested in the details of the machine work I will be glad to supply them.

S. H. Farnsworth.

Chicago, Ill.

Vacuum Pipe Repaired

Early in the forenoon one day last winter I discovered the vacuum had dropped from 28 to 27 in. and was still going down, and when we shut down at noon it had reached 25 in.



Condenser Pipe Split

Such unsatisfactory vacuum denoted something wrong, so I investigated the outside piping of the barometric condenser and found a crack 4 in. long and 1/4 in. wide in the overflow pipe about 25 ft. from the ground. To avoid a shutdown before the end of the week various schemes were tried. First, the millwright filled the crack with waste and covered this up with brown paper shellacked to the pipe, then tried sheepskin, but that also

was disappointing. Glazier's putty was next tried and it held. This soon brought the vacuum to 27 in., but it had to be renewed every day.

The plumbers were finally given the job of putting on Smooth-On cement for a permanent job. We then saw what had caused the pipe to burst—it was full of ice—and to prevent its recurrence, a small supply of steam was piped in to keep the water above the freezing point. I wrapped canvas round the pipe from top to bottom of the crack in the shape of a bandage, then had it painted over.

It is about a year since this happened and the vacuum is as good as it was before the pipe was ruptured.

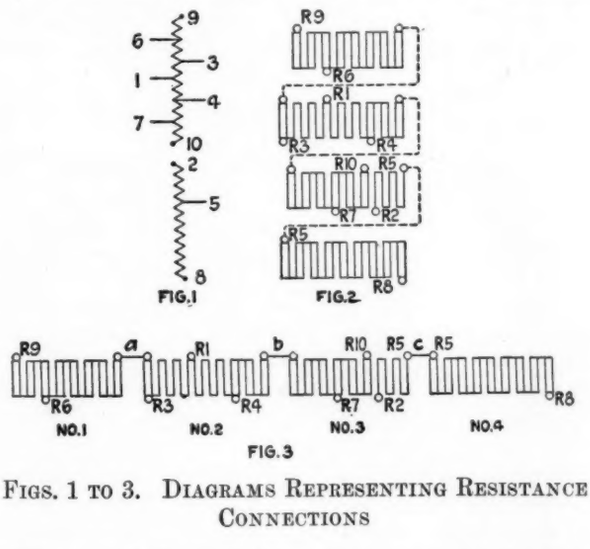
CHARLES SWORD.

Cohoes, N. Y.

Connecting Resistances

When all the terminals of a resistance and the corresponding controller fingers are numbered and the resistance boxes are the same in number and of the same relative size as the ones indicated on the controller-connecting diagrams, then the procedure of connecting the devices is a simple matter. On controller prints, however, the resistances are often so indicated as to make it difficult for the uninitiated to identify corresponding sections and points of the conventional print and of the resistance boxes as received.

A mill operator who was familiar only with continuous-current operation, installed a three-phase, slip-ring induction motor to drive the cylinders for the glazing of gunpowder. His print gave the connections as indicated



FIGS. 1 TO 3. DIAGRAMS REPRESENTING RESISTANCE CONNECTIONS

in Fig. 1 and the resistance boxes as received were in four units, or boxes, as in Fig. 2, in which it will be noted that all the terminals intended to receive controller wires are numbered accordingly, but that the end terminals are not numbered unless they are to receive controller wires. Thus, in Fig. 2, the top box has one unmarked terminal; the next, two and the third, two; and apparently there are no wires to fill them. The unmarked terminals are for the jumpers that connect the several boxes together. On a less involved resistance layout, the object and the manner of realizing it would be more evident. In the present case, the correct location of the jumpers was obtained as follows:

It was noted in the sketch (Fig. 1) that from R_1 one path led to the left through R_3 and R_6 to R_9, and that another path led to the right through R_4 and R_7 to R_{10}. Accordingly, the box with R_1 in the central part, with R_4 to one side and R_3 to the other, was placed upon the floor. It was plain that the next box to be handled had to have R_6 or R_7 in it; therefore, the R_6-R_9 box was laid end-on to the box already placed. As Fig. 1 showed the marks to progress toward the higher number, the second box was placed with the R_6 toward the R_3. Installing jumper *a*, as in Fig. 3, then gave a continuous path from R_1 to R_9. The third box with R_7 and R_{10} in it was then placed end-on to the first box, so that by employing jumper *b*, a continuous progression from R_1 to R_{10} was had. This completed what seemed to be a single long box in Fig. 1, but which was really two boxes and part of another.

There was now only one more to handle and only one place for it. One end was marked R_5, as was also one end of the last box handled. As the latter box had insulation washers that divided it into two parts, it was so placed as to bring the two terminals marked R_5 together; these were then connected by jumper *c*, which gave an independent path from R_2 through R_5 to R_8, just as in Fig. 1. The coils were then marked 1, 2, 3, 4, the jumper connections marked for identification and the boxes placed one above the other in their marked order. It was then noticed that the nameplates were numbered, and if the boxes had been assembled in the order of those numbers in the first place, the positions of the jumpers would have been evident, as the nameplate order was the same as that worked out.

J. A. HORTON.

Schenectady, N. Y.

Putting New Headers in Water-Tube Boilers

In most boiler rooms, the renewal of burnt-out or broken headers in horizontal water-tube boilers is a long and hard job. The following method, requiring little skill and small expense for special tools, has been successfully used.

Two 1-in. steel rods are needed, each long enough to reach from the outside of the front header through the tube to the outside of the rear header, leaving about six inches surplus on either end. Both ends are threaded and fitted with heavy square nuts.

The water tubes, circulation tube and mud-drum nipple are carefully crimped inside the header with an ordinary crimping tool. The header is raised sufficiently to free the mud-drum nipple, by using a crowbar and blocking up with wood blocks. If the tubes have been crimped sufficiently, little trouble will be experienced in drawing the header from the tubes. Some of them may stick occasionally, however, and then one of the rods is run through the tube and used as a battering ram from the other end, knocking the inside of the header and tending to knock it away from the tubes. After it has been loosened in this manner, a slight downward pull will remove it from the circulation tube.

One of the rods is then put through one of the top tubes and the other through one of the bottom tubes. Each rod is run out through the handhole on the other end and, if the boiler is of inclined-header type, through one of the ordinary handhole caps so that the turning-nut will have good bearing surface. If the boiler is of the

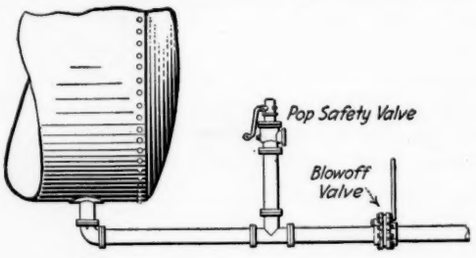
vertical-header type, the handhole caps cannot be used, as they are not set in alignment with the tubes. In this case, pieces of ½-in. iron faced with a wood block to prevent damage to handhole faces must be used. The new header is then fitted into the circulation tube and brought as nearly into position as possible, with the ends of the rods protruding out through the handholes. The caps are fitted over the rods and the nuts put on. Then, by simply tightening up on the nuts and guiding the other tubes into place, the header is drawn up into position and placed over the mud-drum nipple. The tubes are then ready for rolling and flaring, after which the rods are removed and the boiler is again ready for service.

R. T. GRAY.

West La Fayette, Ind.

Preventing Water-Hammer in Blowoff Pipe

The illustration shows a scheme to prevent blowoff failures from water-hammer. An ordinary pop valve is placed between the boiler and blowoff valve on a short riser, to prevent scale from lodging under the valve seat.



SAFETY VALVE ON BLOWOFF

The pop should be set about three pounds heavier than the safety valve on the boiler. On vertical boilers having a greater head of water in the boiler, this will have to be increased to correspond to the head of the water above the valve. The area of the pop should be equal to the area of the blowoff pipe.

CHARLES FENWICK.

Wapella, Sask.

[There would appear to be objection to the foregoing, because the boiler might be drained of water if the safety valve on the boiler should be slightly sluggish or stick at some time. Also, the man blowing down might be scalded if not carefully protected.—EDITOR.]

Oil-Engine Piston Trouble

A short time ago I was called in to locate, if possible, the trouble with an 11x9-in. two-stroke-cycle oil engine. It had recently been installed and was built by a steam-engine company that had entered the oil-engine field. The engineer's explanation of the trouble was that, after starting, the engine would run for about a dozen revolutions and then stop and was even much harder to turn over by hand than when cold.

The engine was one of the hot-ball semi-Diesel types with a long piston. Upon examination I found that the piston diameter was 0.01 in. smaller than the cylinder bore when both were cold, and when heated the head end of the piston expanded more than the cylinder and stuck. I turned the piston down to $\frac{1}{32}$ in. smaller than the cylinder bore, both being cold, and the engine operated satisfactorily. It might be well to add that many oil-engine builders do not allow sufficient side clearance between the piston rings and the grooves, and as a result the rings soon bind and become ineffective, due to carbonization, etc.

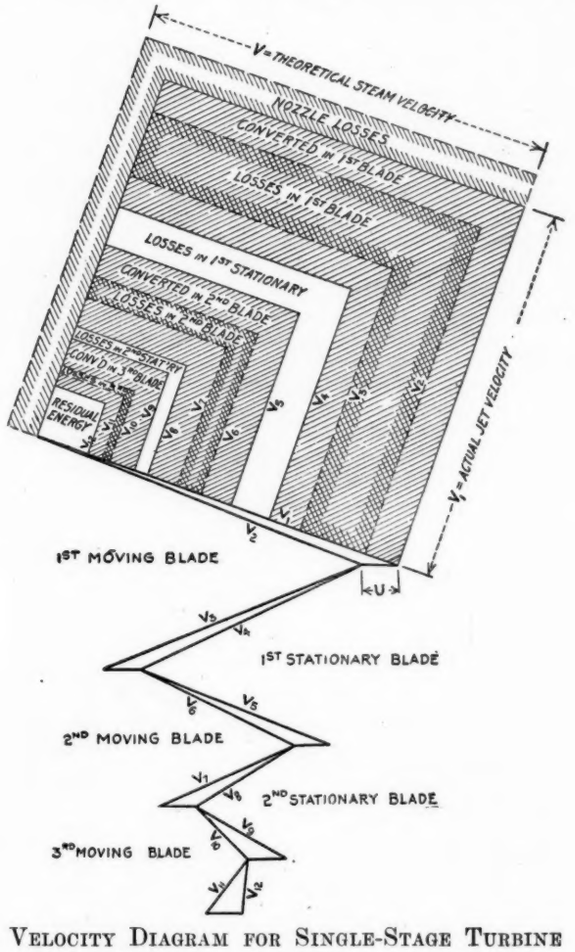
M. E. GRIFFIN.

Franklin, Penn.

Steam-Turbine Diagrams

Mr. Low's article on turbine-velocity diagrams, May 4 issue, considers only the theoretically perfect turbine, when there is no friction or other losses.

It occurred to me that it might be worth while to go a step further, so I have plotted the actual-velocity diagram of a small single-stage turbine having three rows of moving blades. The bucket speed is 225 ft. per sec. The steam is supplied to the nozzles at 160 lb. per sq.in.



VELOCITY DIAGRAM FOR SINGLE-STAGE TURBINE

absolute and expanded therein to atmospheric pressure. The theoretical steam velocity resulting from this pressure drop is equal to about 2920 ft. per sec., but losses in the nozzles reduce this considerably.

The other losses shown are the friction and eddy losses, etc., which occur as the steam passes through the blades. These are proportionally very large in a machine of this size, because the attempt is made to utilize the large energy drop in a single stage. Besides this, the coefficients of loss in this case have been taken well down.

The figures show that about 40 per cent. of the energy of the steam is converted into useful work. This is

represented by the areas shown in simple cross-sectioning. And the water rate of such a turbine would be approximately 40 lb. per horsepower per hour.

PARKER M. ROBINSON.

New York City.

Difficulty in Rotating Piston to Unscrew the Rod

Not long ago I found it necessary to remove the crosshead from a 16x18-in. engine in order to babbitt the shoe. Arrangements had been made at the shop for this work to be done on the following day, and as it was necessary to keep the engine running as long as possible, about an hour's time was allowed to take the crosshead out. The 2⅜-in. piston rod was screwed into the crosshead about 3½ in. It was known to be an easy fit and no difficulty was anticipated.

The start was made quite easily, but the second quarter turn and every turn for the full length of thread was about all that two men could pull on a four-foot bar. After the first few turns I concluded the trouble was due to the piston rings. There were six cast-iron eccentric snap rings ⅜ in. wide and about ⅝ in. deep, tapering to $\frac{7}{16}$ in. at the joint. These rings were doweled to the piston, so that when turning it was necessary to turn them also, and the force being applied to their ends caused them to expand and greatly increase the friction.

This was relieved considerably by turning the engine slowly and turning the piston at the same time. Under these conditions it took nearly four hours to unscrew the rod. The reason this difficulty had not been encountered before on this engine was because the rings had been doweled when the cylinder was removed to make other changes and the cylinder had been slipped off and back on over the piston.

E. P. HAINES.

Baltimore, Md.

Gas Explosions in Boiler Furnaces

Mr. De Blois' letter in the April 20 issue, page 553, regarding his experience with a gas explosion in a boiler furnace, and the letters of comment thereon are highly interesting. The writer's experience, covering many gas explosions of various kinds, leads him to offer another explanation as to the cause.

Taking the conditions as they existed: The ashpit doors were sealed, which would mean that no air could reach the fuel except from the tuyeres or through the door. The boiler was being forced and the coal fed rapidly. From this we must assume that the furnace was more than usually hot and that there was a large quantity of green coal on the side on which the door was closed. As there was no possibility of air getting to this coal from below, it would be subjected to destructive distillation with the consequent evolution of a large volume of gas of a high calorific value. This gas, undiluted with air, would be drawn by the stack draft through the setting, mingling with the air and possibly burning in the rear of, or beyond, the setting. (It is quite possible for two streams of gas and air to exist in adjacent and clearly defined areas, without forming an explosive mixture, particularly if moving in one direction.) The sudden admission of a large amount of air caused a disturbance that resulted in the breaking up and intermingling of the gas and air stratas and the instantaneous formation of an explosive mixture. From the violence of the explosion it would appear that the explosive mixture had filled the setting before ignition took place.

As to preventive measures, one can only suggest that under similar circumstances the other fire-door be left slightly open, to allow sufficient air to burn whatever gas is being formed. The writer would like to know the style of setting, the nature of its connection to the stack, and the amount of stack draft at the fire-door.

S. M. QUINN.

Detroit, Mich.

Commenting on the letter by L. A. De Blois, on the subject of gas explosions in boiler furnaces, it seems that the information given in response to the inquiry sent is not conclusive. Obviously, however, the explosion was due to an improper gas mixture. The writer believes that the importance of proper regulation of draft to meet changes in load has not been given as much attention as it deserves. Most manufacturers of damper and fan regulators emphasize the sensitiveness of their apparatus. Regulators of the open-and-shut, or non-compensated, type are inherently sensitive and will, if in good working order, cause a complete travel of the damper or fan-regulating valve with a slight change in boiler pressure, sometimes under 1 per cent. The writer is of the opinion that, while such regulators make a good-looking record on a pressure gage, their use is rarely justified, and this for the reason that it is not good practice to force a fire of either anthracite or bituminous coal up to brilliant incandescence and then shut the draft off entirely or merely leave the draft due to a short stack. Regulators of the compensated type which cause only partial travel for slight changes in steam pressure are better, but in general they are not compensated enough to prevent results somewhat similar to those produced by the open-and-shut type. Compensated regulators, as received from the manufacturer, will generally give complete travel with steam-pressure variations of less than 2 per cent., and in many plants where the load variation is frequent and considerable this practically amounts to open-and-shut regulation. This type of regulator also makes a good steam-pressure record.

While criticizing the use of such apparatus, the writer is most emphatically in favor of the use of automatic regulators designed so that a considerable variation in pressure will be required to cause total travel of the damper or fan-regulating valve. In most plants a variation in steam pressure of 5 or 6 per cent. is not objectionable, and a regulator which is compensated to require as much variation as this for total travel will subject the fire to much less fluctuation in temperature and in gas composition than a regulator of the type mentioned above. The steam-pressure chart, however, will not be as near a true circle as with the other type; but the charts from the CO_2 recorder will be uniformly higher, and the furnace economy will be perceptibly better.

Emphasis should also be placed upon complete automatic regulation as against a makeshift device such as mentioned in one of the letters published. A control which requires frequent juggling by the attendant in

order to make it cover the requirements is unsatisfactory, because no two attendants have the same ideas and many of them have wrong ideas as to the proper control of draft.

The writer appreciates that the statements made may not apply directly to the conditions described by Mr. De Blois and does not feel qualified to express any opinion as to the probable cause of the accident. There is, however, a point in the design of boiler-flue dampers which should not be lost sight of; that is, that a flue damper should be made short enough so that when it is in the extreme closed position there should be a considerable percentage of opening either at the ends or around the outside edge of the damper. Most manufacturers provide this, but the percentage of opening seems to vary considerably with different makers. I believe that gas explosions, which occur so frequently when banked fires are suddenly put into service, are often due to a lack of sufficient space around the flue damper. This is an interesting and important question, and I hope that it will be thoroughly discussed in POWER.

D. L. BELLINGER.

Glens Falls, N. Y.

In the issue of Apr. 20, page 553, L. A. De Blois gives an account of trouble from gas explosions in a boiler furnace and he invites comment. The installation consisted of three boilers connected to one stack by a breeching, each boiler being fitted with an underfeed stoker. A fire-door was provided on either side of the stoker in each boiler front. One engine-driven blower was connected to the three stokers. It is not stated what type of blower, but I assume that it is of the fan type. It is assumed that the boilers are set in brick and also that there are dampers in the throat connections between the boilers and the breeching.

One boiler only was being operated, the others presumably being cold. Usually, steam is carried on two at a time. The main-stack damper was open and the ashpit doors were sealed. Consequently, the only regulated air inlet is through the blower duct and through the fire-doors when open. The boiler was being forced, and the stoker was feeding coal rapidly. The fireman opened one of the fire-doors and removed a clinker which obstructed the blast tuyere. On the removal of the clinker a gas explosion followed, injuring the fireman. The stack clean-out door was blown open.

We may assume that the explosive was of a mixture of CO and other gases with air. Further reference to other combustible gases than CO will be omitted. If combustion were perfect there would be no CO. If combustion is incomplete we have both CO and CO_2 in the escaping gases; and when the proportion of the CO to the CO_2 is about six to one we have a condition desired in a gas producer. When a fan-blower discharge pipe is closed or obstructed the quantity of air flowing is reduced. This condition is often met with in cupola practice. A tuyere becomes obstructed with slag, cooled by the blast; and until the slag is removed the flow of air is reduced and, consequently, the temperature of the bed.

If we are correct in our assumption of the quality of the explosive mixture, where does the mixture come from? Much coal is being fed into a hot fire; the admission of air is checked, CO is produced, and the temperature of the furnace drops. On opening the fire-door more air is admitted and the furnace temperature is further lowered. Probably, if nothing more were done at this time and the door were left open, there would be no explosion, as the increased draft would carry off the combustible gases. But if the air flowing in at the door and the CO already generated do not immediately make an explosive mixture, one must look for another air inlet. There remain two other possible sources—the throat dampers of the cold boilers and leaks in the boiler setting. Under proper forced-draft conditions there is one of two conditions in the boiler spaces—a plenum or a balance. Under either there will be little or no inflow of air through leaks. But there is no plenum and no balance, because the proper openings for the admission of air are obstructed and because the stack is trying to pull as the damper is open. There is a partial vacuum in the boiler spaces. My recollection is that tests carried out by Professor Breckenridge on a new battery of brick-set boilers at the St. Louis Exposition showed that the inflow of air through the settings was large, and that he mentioned a case in which the quantity of air so inflowing amounted to 30 per cent. of the total stack gases.

Assuming that air did flow in through the settings or through the throat dampers of the cold boilers, or both, there is a mixture of CO and air, and possibly in proportions necessary for rapid combustion. The temperature in the boiler spaces is comparatively low, the draft is reduced, and the gases are not promptly removed. There is now an explosive mixture awaiting some condition necessary to combustion. The fireman removes the obstructing clinker from the blast tuyere, intense heat and flame are produced locally, the flame and the explosive mixture come together, and an explosion follows.

I have said that the air flowing in through the open fire-door probably did not mix with the CO to form the explosive gas in large or dangerous quantity, for the reason given, and for this additional reason: In hand-firing fresh fuel is added through an open door, air also enters through the opening, but a heavy explosion does not always follow. Therefore, fresh fuel and an open door are not necessarily the cause of an explosion. Yet with heavy hand firing and checked draft, even in the case of internally fired boilers, there do occur "puffs," which are due to the rapid burning of a small quantity of comparatively confined gas. If there is a quantity of explosive gas in the boiler spaces, there will be explosion on the introduction of flame.

It may be suggested that I have not given a sufficient reason for the checking of the draft. Possibly there is another reason. The throat connection between boiler and the breeching may have been large enough for the normal rating of the boiler, but not quite large enough when it was steaming at much above rating. Again, when three boilers are connected by a breeching to one stack set at one end of the breeching, the cross-section of the breeching at the further end is usually calculated for one boiler at a little above normal rating. We do not know that the connections were arranged in this way, but we know that the boiler was being forced.

Because the foregoing is largely conjectural and inferential, I cite the following experience: In 1888 I was assistant engineer on some tests instituted in order that the best way to fire boilers with oil-gas might be learned. One of the boilers used was a two-furnace Scotch boiler. The furnace mouths were closed by removable iron plates.

Oil-gas and air were introduced through mixer burners; the oils experimented with were Astatki and American crude petroleum. These tests were made at North Greenwich, London, Eng. Oil from abroad was usually shipped in barrels. The Baku oil line had not then been built, and tank ships were not in general use. The tests were successful so far as evaporation of water per pound of oil was concerned, but were stopped when the price of crude petroleum jumped to 6d. (12c.) per gallon on the dock; the price of London steam coal being at the time 17s. ($4.08) per long ton.

The oil was vaporized in a producer by steam, in some tests superheated (with results which those who have tried it know), in others saturated, and in still others saturated with a later addition of superheated. We learned that a brick baffle before the burner or, better, around it was necessary. Pockets of water which were present in the oil of course gave no oil-gas; the flame went out; and when the pocket was exhausted and oil-gas again flowed from the burner the incandescent brickwork reignited the gas. It should be said that what we called gas was in reality a vapor and not a fixed gas.

On one occasion, soon after lighting off, the flame went out for a moment. The coverplates had not been put in place. An attendant threw a bunch of lighted oily waste into the furnace to ignite the gas when it came on again. But it had already arrived. The explosion was violent, and the brickwork in the combustion chamber (dry) was loosened. I had other proof of the force of the explosion, for I was standing immediately in front of, and only a few feet from, the boiler when the bunch of waste was thrown into the furnace. There was no other explanation than that the furnace and the combustion chamber were filled, the former partly and the latter probably completely, with an explosive gas. Did not the combustion chamber, breeching and stack base mentioned by Mr. De Blois contain an explosive gas? The stack clean-out door was blown open.

A later experience, and one more like that of Mr. De Blois, was as follows: About eighteen months ago I was asked to make an investigation and report on a case of boiler-furnace explosion. There were two boilers connected through a breeching to a brick stack, and both were hand fired. This fact is of some importance. When both were under steam firing was light and no trouble was experienced. To save fuel it was decided to try to use only one of the boilers at a time, holding the other in reserve, and cold. The fuel used was bituminous run-of-mine, with an occasional addition of wood shavings and sticks. A pile of shavings had stood on the boiler-room floor about ten feet from, and opposite to, the first boiler. On one occasion there had been an explosion, and flame had leapt across the boiler-room floor and had set fire to the pile of shavings. On the latest occasion, coal only being used as fuel, the fireman had covered the fire with a layer of rather fine coal. A little later he opened the door, and finding the fire deadened, stirred it with a poker or slice bar. Immediately, there was an explosion. The fireman was thrown across the room and was badly burned.

The manager of the plant argued that the cause could not be poor draft due to insufficient stack capacity, as this particular boiler installation had been in use for about twenty years and furnace explosions had been a recent experience. On examining the settings I found clean-out doors in the rear which could not be closed tightly (one could see about three-eighths of an inch of red light through the opening of the door of the live boiler); several large cracks in the brick walls; unnecessarily large holes in the walls where the water-gage connections and other pipes entered; open joints and empty rivet holes in the breeching; front doors not fitting closely. I advised that all setting leaks be stopped and the results noted. I heard of no further trouble. On reading Mr. De Blois' letter I called up the manager of the plant, and he told me that he had had the leaks stopped and that while there were little puffs or explosions now and then, they were neither as severe nor as frequent as they had been. Other running conditions were about the same as before.

I have said that the fact that the boilers were hand-fired was of some importance; it shows that explosions are not characteristic of stokers. The stoker was not necessarily at fault.

It is interesting to note that in this, as in Mr. De Blois' case, one boiler only was being operated. In this case it will be seen that there was no blast tuyere to become obstructed, but there was what amounted to the same thing—heavy firing with a close-lying coal, which obstructed the air passages through the grate and fire; and insufficient draft to pull air through the fire. There was also enough air leakage through the settings to make an explosive mixture with the CO and other gases generated, and there was sufficient local heat at times to fire the explosive mixture.

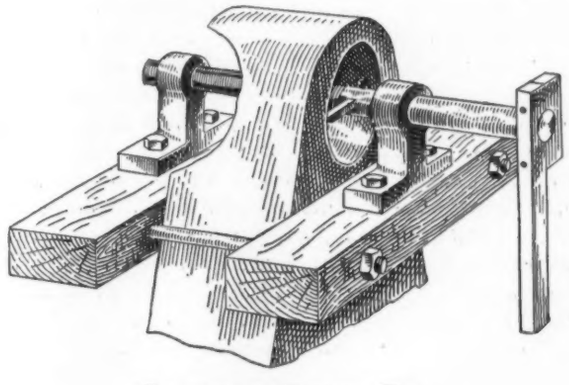
ARTHUR SCRIVENOR.

Richmond. Va.

Enlarging Crankpin Bore

When the crankpin of our ammonia compressor worked loose we decided to remove it, enlarge the hole in the crank and shrink in a new pin.

To do the job cheaply and quickly a 1⅝-in. shaft, 28 in. long, was threaded on one end with 30 threads to the inch. A ⅜-in. hole was drilled through the shaft to carry the cutting tool, the latter being held by a setscrew. Two 4x4-in. wood blocks, each 2 ft. long, were clamped to the crank and each had a bearing for carrying the shaft of the small boring bar. The arrangement is shown herewith.



IMPROVISED BORING BAR

J. H. CUNNINGHAM.

Toledo, Ohio.

Grit in the Feed-Water Meter

Recently, the writer experienced considerable trouble with a Kennedy-type water meter. On opening it considerable fine coal grit was found. The puzzle was, how did it get there? The source of supply had not been changed, and this difficulty had never arisen before.

The overflow pipe from the injector had, temporarily, been put to discharge near the coal bin, and this pipe sometimes got covered over with coal when the bunkers were full. In this particular style of injector, a vertical one handling 23,000 pounds of water per hour, unless the correct amount of water is put on to suit the steam, a considerable suction can be felt at the overflow pipe, probably due to the check valve on the combining nozzle not seating tightly, so that it drew quite a little coal dust up the overflow pipe, discharging it into the feed line and meter.

E. R. Pearce.

Rochdale, England.

Influence of Ash Content

I read with interest Mr. Ellis' letter, "Influence of Ash Content of Coal," in the Nov. 3 issue.

High ash certainly cuts down furnace efficiency; on that point there is no argument. Mr. Ellis states that "coal apparently follows a straight-line characteristic as regards its value on a basis of its ash content, assuming the same character of coal." If by "same character" Mr. Ellis means any general class such as anthracite, semi-anthracite, semibituminous or bituminous, I take exception to his statement.

For a given coal I will concede the straight-line characteristic, but I do not see how one characteristic can be applied to all coals of the same character. For instance, in anthracites the heat of combustible or ash-free heating value, as it is sometimes called, varies from 14,400 to 15,200 B.t.u. With 15 per cent. ash, the B.t.u. dry in these limiting conditions is 12,240 and 12,920, respectively, a variation of 680 B.t.u. per lb. On this basis, it would appear to be advisable not only to keep the ash down, but to buy heat and not to accept the absence of ash as an indication of high heat. Low ash may or may not indicate high heat. The calorimeter answers that.

The formula at the end of the letter would, perhaps, have been better understood if an example had been worked out. As it stands, the "value of coal" increases numerically as the ash content increases, which is just the reverse of what Mr. Ellis stated. For instance, take a coal having an ash-free value of 15,000 B.t.u. and assume that two subsequent shipments show 10 per cent. and 20 per cent. ash, respectively. Assume the price delivered to be $3.50 per ton. The B.t.u. of the first shipment are 13,500 and of the second shipment, 12,000.

The value of the first shipment by the formula is then

$$\frac{350}{13{,}500 - (13{,}500 \times 1.5 \times 0.10)} = \frac{350}{13{,}500 - 2025}$$

$$= \frac{350}{11{,}475} = 0.0305$$

The second shipment shows a value of

$$\frac{350}{12{,}000 - (12{,}000 \times 1.5 \times 0.20)} = \frac{350}{12{,}000 - 3600}$$

$$= \frac{350}{8400} = 0.0417$$

From this it appears that the worse the coal, the higher its value, as given by the formula. If it is correct, will Mr. Ellis state how much better he regards the first shipment than the last, based on the figures given by the formula?

Carleton W. Hubbard.

Brooklyn, N. Y.

Questions for Discussion

Gasoline Engine Run on Natural Gas

We purchased a gasoline engine that was taken out of a wrecked automobile. It is a 5x5-in. six-cylinder engine rated at 60 hp. when running at 1000 r.p.m. We are repairing this motor and intend to connect it through a flexible coupling to a 750-r.p.m., 17½-kw. generator to furnish power for our after-midnight load. The engine will be operated with natural gas and the speed controlled by a flyball governor mounted on the fan shaft and connected with levers and rods to butterfly valves in the air and gas intakes.

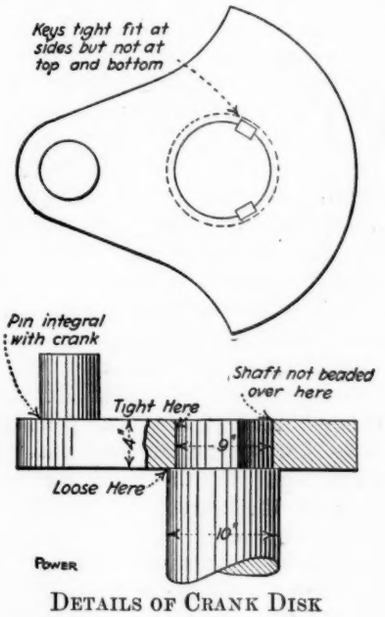
Have any readers of Power had practical experience with this type of engine operated on natural gas? If so, I should be glad to have suggestions as to how they have overcome the speed-governing problem, also as to what proportion of power the engines developed with natural gas in comparison with gasoline.

Erwiss Gawthrop.

Pittsburgh, Penn.

Loose Crank Disk

Can any of the readers of Power suggest some means of tightening a loose crank disk on a large high-speed engine without removing it? The disk was shrunk on



Details of Crank Disk

the shaft about three months ago, after being carefully calipered and fitted by a man thoroughly experienced in such work, but in a few weeks it was apparently as loose as the one it replaced.

M. A. Jensen.

Nebraska City, Neb.

Inquiries of General Interest

Effect of Inside Lap—What is the effect of adding inside lap to a slide valve?

J. W. D.

By adding inside lap the exhaust port is closed earlier, thereby resulting in higher compression of the exhaust.

Corrosion of Steel Uptake—What would cause our steel stack and uptake to corrode more rapidly than formerly?

N. R.

Other things being equal, more rapid corrosion would take place from use of fuel containing more moisture or more sulphur, or from introduction of more moisture with the air supply to the furnace.

Slope for Drainage of Boiler to Blowoff—How much should the rear end of a return-tubular boiler be set lower than the front end for drainage toward the blowoff?

F. W. S.

Sufficient slope for drainage is usually obtainable for boilers 16 to 18 ft. long by setting the blowoff end about 2 in. lower than the front end.

Quality of Boiler-Feed Water—What proportion of scale-forming substances may be contained by a water to be considered as good or poor boiler-feed water?

L. G. N.

Water containing 8 to 10 grains of boiler-incrusting substances per gallon may be considered as good, while those containing 15 to 20 grains or more may be regarded as poor.

U. S. Navy Composition Metal—What is the U. S. Navy composition or steam metal?

J. M. C.

This is a composition metal consisting of 88 per cent. of copper, 10 per cent. of tin and 2 per cent. of zinc. Its tensile strength is about 32,000 lb. per sq.in. and its elongation about 25 per cent. On account of its strength and toughness this composition is considered superior for valves, flanges and other boiler accessories.

Danger to Cylinder from Sudden Overloading—Does overloading a cutoff engine have any tendency to blow out a cylinder head?

G. M. S.

In case of overloading, the higher velocity of steam in the steam pipes and passages has a tendency to suddenly sweep into the cylinder any accumulations of condensation and thereby endanger the cylinder and its head to rupture from presence of water in the cylinder.

Receiver of Returns Should Be Vented—Where a low-pressure heating system is supplied with live steam passed through a reducing valve and there is no vacuum pump on the returns, is it necessary to discharge the returns either to an open tank or into the atmosphere?

M. J. N.

Where the piping is properly arranged for drainage the returns may be collected in a closed receiver with an automatic air-relief valve, though it is better to supply the receiver with an air vent that is always in communication with the atmosphere.

Omission of Low-Down Tubes in Return-Tubular Boilers—In return-tubular boilers, why is not the space generally utilized for tubes on each side of manholes and handholes in the lower part of the flue sheets?

L. G. J.

Tubes placed low down in the flue sheets are not favorably located for receiving the flow of the gases from the combustion chamber and are thus of little value as heating surfaces. By their presence in the lower part of the boiler they not only displace a substantial amount of water which should be present to absorb the direct heat of the fire, but also impede circulation in a part of the boiler where it is most needed.

U. S. Navy Standard Boiler Compound—What is the composition of U. S. Navy standard boiler compound?

A. N. I.

This compound consists of calcined sodium carbonate, trisodium phosphate, dextrine or starch, and a tannin compound such as mangrove bark, cutch or catechu. These materials are intimately united by thorough digestion, dried, finely powdered, well mixed and readily soluble in water. The compound must show on analysis at least 76 per cent. of anhydrous sodium carbonate (Na_2CO_3), 10 per cent. of trisodium phosphate ($Na_3PO_4 12H_2O$), 1 per cent. of starch, and sufficient cutch to yield 2 per cent. of tannic acid, the remainder consisting of water and such impurities as are common to the ingredients.

Use of Iron in Place of Copper Feed-Water Tubes—A closed feed-water heater now fitted with copper tubes is capable of warming a uniform supply of boiler-feed water from 50 to 190 deg. F. To what temperature would the feed water be heated, using the same number and size of iron tubes?

J. H. B.

By the use of iron in place of copper tubes the rate of heat transmission would be about two-thirds as great as with copper tubes and the temperature of the water would be raised to about

$$50 + \tfrac{2}{3} \text{ of } (190 - 50)$$

or approximately to 143 deg. F.

Saving from Higher Evaporation per Pound of Coal—What percentage of fuel is saved with an equivalent evaporation of 9.5 lb. of water from and at 212 deg. F. per lb. of coal over an equivalent evaporation of 8 lb. of water per lb. of coal?

L. S. F.

With an evaporation of 9.5 lb. of water per pound of coal each pound of water requires $\frac{1}{9.5}$ of a pound of coal. With an evaporation of 8 lb. of water per pound of coal each pound of water requires $\frac{1}{8}$ of a pound of coal. Therefore, when the evaporation is at the rate of 9.5 of water per pound of coal, $\frac{1}{8} - \frac{1}{9.5}$ lb. of coal is saved for each pound of water evaporated and the saving amounts to

$$\left\{\frac{\frac{1}{8} - \frac{1}{9.5}}{\frac{1}{8}}\right\} \times 100 = 15.78 \text{ per cent.}$$

Size of Safety Valve for Compressed-Air Tank—What size of pop safety valve should be used for a compressed-air tank supplied from a compressor having a rated maximum capacity of 130 cu.ft. of free air per min. compressed to 100 lb. per sq.in. gage pressure?

P. E. C.

The safety-valve capacity should be 25 per cent. in excess of the rated maximum capacity of the compressor, or

130 + 25 per cent. of 130 = 162.5 cu.ft. per min.

and the size of valve required may be determined from the formula,

$$Q = 28\ PDl, \text{ or } D = \frac{Q}{28\ P\ l}$$

in which

Q = Discharging capacity of the valve in cubic feet of free air per minute = 162.5 cu.ft.;

D = Size of valve in inches;

P = Absolute pressure of air relieved by the valve = 100 + 14.7 or 114.7;

l = Lift of valve, which for standard pop valves may be taken as $\frac{1}{31}$ of D.

By substituting in the formula and solving for D,

$$D = \frac{162.5}{28 \times 114.7 \times \frac{1}{31} D} = 1.25$$

that is, a 1¼-in. safety valve should be used.

The Electric Traction Elevator*

Elevators may be classified first according to the driving power employed, which gives three principal classes, namely, steam-driven, hydraulic and electric elevators.

The first class is now practically obsolete. There are, of course, a few of them still running, but there are no new installations.

Hydraulic elevators may be divided into several groups, depending upon the method in which the hydraulic power is applied. Some of these types are: The horizontal, rope geared; the vertical, rope geared; and the plunger, which is direct connected. The plunger type practically superseded other types of hydraulic elevators during the period of 1904 to 1907, but has itself been almost entirely superseded by the 1 to 1 gearless electric-traction type.

Without considering in detail the technical features of the plunger elevator, the principal reasons for this change may be summarized in its comparison with the gearless traction type as follows:

1. Higher initial cost of plunger installation.
2. Larger amount of total space in the building occupied by the machinery.
3. Lower car mileage and consequently more elevators required for the same service.
4. Higher power consumption.

As to the location of the electric elevator, this is preferably directly over the hatchway, an arrangement which gives the best traction, least amount of ropes, minimum space required, longer rope life and higher efficiency.

The roping is extremely simple, usually six ropes of ⅝-in. diameter being used. The material is soft steel and in actual installations there is generally a safety factor of not less than 12. Each rope is provided with a self-adjusting rope hitch of the ball-and-socket type, which, owing to gradual creeping, prevents any excessive twisting stress and relieves the usual bending stresses at the hitch, caused by vibration.

A traction machine is arranged so that in case of overrun at the terminals either the car or the counterweight strikes an oil buffer, thereby reducing the traction sufficiently to prevent further motion of the car, even if the motor keeps on running. The car buffer is of the spring-return type and is mounted in the bottom of the pit.

The counterweight equals the weight of the car and usually about 40 per cent. of the maximum load. If we consider an elevator of 2500 lb. lifting capacity, 40 per cent. of this equals 1000 lb. (the overbalance) and this represents about six or seven persons. With such a condition of loading it is apparent that there is no net load to be lifted and, therefore, the only power required is for acceleration and to overcome friction and electrical losses.

ROPE COMPENSATION

It is obvious that with a high-rise elevator the variation in the net load on the elevator machine due to the shifting of the weight of the hoisting ropes from one side to the other as the car moves up and down would be excessive if this was not compensated for. This compensation is usually obtained by means of chains or ropes attached to the car and counterweight and running down the hatch in a loop. The weight per foot of these compensating ropes is such that, together with the electric cables that lead to the car, they compensate fully the weight of the hoisting ropes for all positions of the car.

For all high-speed, high-rise elevators compensating ropes are used and in the pit a tension device is provided for the compensating ropes. For moderate rises and comparatively low speeds, chains are used instead of ropes.

DRIVING MOTOR

The motor is of the slow-speed type, generally having six poles and provided with a shunt field only. The armature is series wound with conductors of rectangular cross-section in order to get in the maximum amount of copper. With a 36-in. driving sheave, a car speed of 600 ft. per min. corresponds to 63.5 r.p.m. of the motor armature.

For a considerable time it was considered that such a slow-speed motor delivering around 35 hp. would have an exceedingly low efficiency, but this is not the case. On the contrary, it has been demonstrated that a motor with this low speed can be designed to have just as high efficiencies as any high-speed motor.

Passing now to the different parts of the hoisting engine, the driving sheave is mostly 36 in. diameter, is cast integral with the brake wheel, and is bolted to the armature sleeve or spider. Circular rope grooves are employed. The magnet brake is of the shoe type, usually provided with a series winding for quick release and a shunt winding for holding. The brake shoes are lined with fabricated asbestos. The gradual and soft application of the brake is obtained by magnetic retardation of the magnet cores. The brake shoes used to be lined with leather, but after exhaustive tests of a number of different braking materials it was found that a certain kind of fabricated asbestos was the most suitable, its particular characteristics being that the friction between the lining and the brake wheel is constant at all times.

Elevators of the gearless traction type have been for some time equipped with ball or roller bearings. These are used for both the main motor and the rope sheaves. This was done primarily to gain space, because it is readily apparent that these anti-friction bearings take up much less room than the plain solid bearings. Personally I consider ball bearings superior to roller bearings for elevator machines. With roller bearings slightly out of alignment, even though this be insufficient to set up destructive strains, the friction will be increased materially. As a matter of fact, actual tests have shown that friction induced in this manner can readily be in excess of the friction in a plain bearing. Ball bearings are capable of resisting a certain amount of end thrust, which in the case of these traction machines is sufficient to take care of the "float" of the armature, caused partly from magnetic action and partly by the action of the hoisting ropes. Roller bearings will permit of no end thrust at all, and therefore, when they are used additional means must be provided to take care of this.

It is necessary, of course, to provide some lubrication in a ball bearing so as to prevent cutting, particularly of the cage; therefore, grease is provided, which will stay in the bearing. Furthermore, grease is most efficient in ball bearings for elevator machinery to prevent corrosion of the balls and races. A little rusty speck on either the race or a ball will soon destroy the bearing; hence these bearings must be usually well protected. If the grease is wiped out and the bearings run perfectly dry, the apparent friction losses will have been reduced to about one-fifth of that with lubrication.

SPEED CONTROL

Speed variation is obtained partly by field regulation and partly by series and bypass resistance in the armature circuit. The field regulation is usually capable of reducing the speed down to 60 or 40 per cent. of full speed, and further reduction is obtained by resistance control, as previously mentioned.

The combination of both methods is necessary to obtain sufficiently slow speed—about 60 ft. per min. This slow-speed car is required to make accurate stops both at intermediate and terminal landings and also in order to be able to make a very short travel or to "inch up or down to the landing."

In connection with the regular operating features of the control apparatus, there are also a number of other features introduced for safety. Some of these are:

1. Automatic return of car switch to off position.
2. Automatic stopping switch on car for stopping at terminal landings.
3. Final cutout limit switches in hatchway, operating independently of the automatic stopping switch.
4. Automatic stopping of elevator in case of over-speed by means of an electric contact operated by a centrifugal governor which will apply the electromechanical-brake and dynamo-brake effect on the armature, and, finally, the electric safety on the car.
5. Oil buffers, as previously mentioned, are capable of independently stopping the fully loaded car when descending at 50 per cent. excess speed without discomfort to the passengers.
6. Regulation of the shunt field by centrifugal governor to maintain constant full speed with variable loads.
7. For high-rise elevators the use of a retarding and latching device.

LOADS AND SPEEDS

Gearless traction machines utilizing 1 to 1 or 2 to 1 roping have been built for loads varying from 2000 lb. up to 11,000 lb. at car speeds from 350 to 700 ft. per min. Of these duties the most generally used for the modern high office building, utilizing 1 to 1 roping, is about 2500 lb. at 600 or 700 ft. per min., although in many instances a load of 2500 lb. at 500 or 550 ft. per min. is suitable. The high rise elevators in the Woolworth Building run at a speed of 700 ft. per min. In the new Equitable Building certain of the elevators are arranged to run a portion of their travel on express service at a speed of 650 ft. per min., and the remainder of their travel on local service at 550 ft. per min. The change in car speed is automatically accomplished at the point where the service changes.

*Excerpts from an address of David Linquist, chief engineer of the Otis Elevator Co., before the New York Section of the American Society of Mechanical Engineers.

For more moderate speeds and also for the heavier loads 2 to 1 roping is utilized, which retains the same safety features and general characteristics as in the 1 to 1.

The traction principle is also applicable to elevator machines employing moderately high-speed motors with some form of gearing between the motor and the driving sheave. This type of machine is most suitable where lighter capacities are involved or where the service conditions are not so severe. Under these conditions the power consumed will be comparatively light on account of the small mileage, and hence the more expensive gearless machine with its reduced power consumption may not be necessary.

Two types of geared machines have been developed—one employing worm gear and the other herring-bone gear reduction. Of these the worm gear is suitable for the slow or more moderate speeds and is extensively used for this purpose. The machine with herring-bone gear reduction is not suitable for slow car speeds on account of the difficulty in obtaining sufficient speed reduction. It is undoubtedly more efficient than worm gearing, and it has been used with some success in connection with quite high-speed elevators. The fact that the herring-bone gear has been used for these high speeds does not mean that it is to be considered equal to the gearless machine, with which it cannot compare as to operating features and power consumption. The worm gear has inherently the least tendency to vibrate, but the herring-bone gear is generally more efficient.

The maximum efficiency of the high-speed motor used in connection with the geared machine may be practically as high as that of the gearless, but the efficiency at lighter loads, which is the most prevalent running condition, is lower; hence, the high-speed motor is at a disadvantage. Equal amounts of field regulation may be applied to both types.

For high speeds it may be taken that under the best conditions the gearing has a loss of about 10 per cent.

ELECTRO-MECHANICAL SAFETY DEVICES

1. The safety should be so arranged that the application of a predetermined but definite light retarding force will stop the car and net load without shock in case the hoisting ropes are intact.

2. The safety device should be so arranged that the application of a predetermined definite strong retarding force will gradually bring the car and maximum load to rest in the case of a free falling car.

3. The light retarding force should be immediately applied, preferably by means of a centrifugal governor, in case the car should attain excessive speed in either direction.

4. It should be possible to immediately apply the light retarding force from within the car when desired.

5. The light retarding force should be applied automatically in case of overrun at the upper or lower terminals, and be arranged not to interfere with the starting of the car in the opposite direction.

6. The strong retarding force should start to apply the instant the hoist ropes part, independent of the speed of the car and counterweight. In safe lifts a strong retarding force should be automatically applied independent of the parting of the hoisting ropes at a definite speed which should be higher than the speed at which the light retarding force is applied.

7. A tripping governor should not be necessary to apply the strong retarding force.

8. The releasing carrier, even though improperly adjusted, should not prevent the application of a strong retarding force to the car in case the ropes parted.

9. The principal actuating parts of the safety should be made to move automatically at frequent intervals, in order to prevent them from clogging up or corroding together. This motion of the actuating parts need only be very small to give the desired results, but some motion is necessary to secure dependable action of the safety.

The light retarding force is obtained by one helical steel spring forcing the curved wedges between the rollers of the safety jaw. When the car is in service this spring is held under compression by means of an electromagnet.

DISCUSSION

Some questions were asked with reference to the rope strains. In reply Mr. Linquist stated that under ordinary conditions the apparent safety factor with the load at rest was never less than 12. This did not take into account the additional stress due to acceleration and bending of the rope, which would make the real safety factor hardly over 8.

As to whether anything had been done with reference to the employment of alternating current in electric elevator service, the speaker replied that, up to the present time no alternating-current elevators have been put on the market of the direct-connected or gearless traction type. Those in use are of the geared type, for speeds up to 350 ft. per min. approximately. For 250 to 300 ft., two motors are employed, with a speed variation of from 1 to 3 down to 1 to 4; in other words, the reduction of speed is to ¼ or ⅓. The change in speed is obtained by rearrranging the connections of the motor in such way as to change from a small number of poles giving the high speed to a large number of poles giving the slow speed.

With reference to the smooth application of the brake, no known method has been used for magnetically retarding an alternating-current brake. There dashpot retardation has to be employed, and in the majority of cases the brake-magnet parts are inclosed in coil-type casings and the brake-magnet cores are formed partly for plungers to act as dashpots.

Going back to the question whether anything has been attempted in the line of gearless alternating-current traction machines, Mr. Linquist stated that last year he had built such a machine. Half of the outfit consisted of an alternating-current motor, and at the same time it acted as a motor it also acted as a converter. The other half of the machine consisted practically of a direct-current motor with a revolving field with unusually large speed variation and speed regulation. The machine was built and tested, and so far as the speed control was concerned it was perfect. There was field regulation from no speed up to full speed, and it was possible to obtain any desired speed without resorting to resistance control. On the other hand, the losses were comparatively high and the efficiency was not very good. As far as operation was concerned it was successful, but considering the cost of operation and first cost, it was hardly a commercial proposition, because as good results and perhaps better could be obtained by changing the alternating current by means of converters or motor-generator sets into direct current and operating direct-current elevators.

Electric Ship Propulsion

Before a joint meeting of the Western Society of Engineers and the American Institute of Electrical Engineers, W. L. R. Emmet, of the General Electric Co., gave an interesting talk on the above subject on the evening of Apr. 26. The development of the high-speed turbine paved the way for electric ship propulsion. Its application in this field had been long foreseen. Mr. Curtis had worked for two or three years on the problem, and since 1900 Mr. Emmet had spent much of his time on the turbine. About six years ago he had first approached the Navy with a view to equipping battleships for electric drive, but at about the same time the question of reduction gearing had been brought to the front and the Navy had been impressed to the extent that the collier "Neptune" was equipped with turbines and reducing gears. The excellent results obtained aroused interest in the general question of reducing the speed between the turbine and the propeller, and as a result Mr. Emmet secured the contract to equip the "Jupiter" electrically. During the two years this ship has been in service it has made a wonderful record. Results 20 per cent. better than from any ship afloat have been obtained, and the equipment is as good as new. The turbines run regularly on a water rate of 11 lb. per shaft hp.-hr., which may be compared to 14 lb., the best obtainable from a triple-expansion-engine-driven vessel. Naturally, electric propulsion gained in favor, and about a year ago it began to be thought of seriously for battleships. As the advantages of the electric drive increase with the power required, Mr. Emmet had been particularly anxious to equip a battleship, and only within the last few days the contract for the "California" had been closed. An estimate on the cost of installing electric drive showed that a saving of $160,000 would be effected over the cost of the turbine equipment that had been previously planned. In these large powers all sorts of complications arise when the turbines drive the propellers directly or through reduction gearing. With the latter the power must be divided up between a large number of units, as there is a limit to the size and capacity of individual gears beyond which it would not be safe to pass. In ships where the turbines drive the propellers directly there must be a compromise in speed. The turns made by the propellers are much too high, and the turbine runs at about a tenth of the speed it ought to have to give the best results. Besides, there is great complication of piping for high- and low-pressure turbines, and as the pressure in some of this piping is below the atmosphere, air leaks are liable to develop and lower the efficiency by reducing the vacuum. On the other hand, with the modern electric drive the loss cannot exceed 8 per cent. The apparatus is designed so that practically a constant water rate is maintained for all loads.

In the "Lusitania," with a speed of 180 r.p.m. the propeller efficiency is 62 per cent. The turbines for the "California" will have a speed of 2200 r.p.m. and deliver to the generator 75 per cent. of the available energy in the steam. In the

latter the turbines will be simple, compact machines, while those of the "Lusitania" are enormous. By dropping the propeller speed of the "Pennsylvania" from 222 to 160 r.p.m., the efficiency would be increased 8 per cent., which would just counterbalance the loss by electric propulsion. Comparing the present equipment with an electrically propelled "Pennsylvania," the efficiencies would bear a ratio of about 63 to 73 per cent.

Investigating the possibilities of reduction gearing held back electric propulsion. Parsons had condemned the latter and favored gears. Reduction gearing has proven successful on small ships running at moderate speeds. As the speed of the vessel increases, however, the ratio of reduction between turbine and propeller speeds becomes greater and the gear problem is more difficult. The General Electric Co. had become interested in gearing and developed a system which was installed on three freighters equipped with turbines. These gears may be applied to cases where electric propulsion is barred, but in the favorable cases the speaker could not imagine any arrangement of gears which would be anywhere near as good as electric drive.

Electric propulsion is to have a wide field of application. The company had recently figured on two large Russian cruisers and on a number for our own navy. Mr. Emmet stated that he could reëquip the "Lusitania" and save $150,000 per year in the cost of coal. Electric drive for liners so far exceeds engines that the equipment would pay for itself in one or two years.

Slides were thrown on the screen showing the 20,000-ton collier "Jupiter" and its power-plant equipment. At 15 knots the vessel requires 7000 hp. The generator is of simple and rugged construction and is not restricted as to voltage or frequency. It has a capacity very little greater than required by the motors, so that even a short circuit would not result in much injury. The motors are of the three-phase induction type, the stator having bar windings and the rotor a definite wound design provided with external resistance to be used when reversing. The governor is designed much like a tachometer with a system of fulcrums which can be moved in and out and varied through a wide range of speed.

For the "California" each turbine will have a maximum capacity of 18,000 shaft horsepower and on maximum load will require 170,000 lb. of steam per hour. The vessel has a displacement of 30,000 tons and a maximum speed of 22 knots, and yet each of the two turbines driving it is only 14 ft. long. The motors are 12 ft. in diameter by 11 ft. wide. Consequently, the entire equipment occupies comparatively little space, and the first impression would be that it was designed for a tugboat or at least a vessel much smaller than the "California." Even the auxiliaries will be electric driven, and the only steam piping entering the engine room will be the two leads for the main turbines.

The two turbines will develop a maximum of 36,000 hp., which is required to force the vessel to 22 knots. At 14 knots 7000 hp. is required. Performance charts showed that the water rates will remain practically constant over a wide range of speed. At 14 and 21 knots it was 10¾ lb. per shaft hp.-hr., and for the range in speed between these two points it remained between 10 and 11 lb. At a speed of 15 knots, 28½ in. of vacuum, no superheat and 190-lb. gage pressure, the "Jupiter" showed a performance of 11 lb. per shaft hp.-hr. These figures are exceptional and can be obtained only when both the turbine and the propeller are running at their most efficient speeds. By diminishing the excitation with the speed the efficiency is maintained and at the same time the torque is not reduced beyond that which is required. It is simply a case of diminishing the excitation until the propellers are turned at the right speed with the minimum amount of steam. One of the big problems is reversing, but it has been met by using high excitation while the change in direction is taking place.

With the reduction gear the great problem has been to equally distribute the load over the entire face of the gear. With a rigid gear most of the load is applied near the ends of the teeth. In the General Electric design this difficulty has been overcome by a gear made up of separate disks which will give sidewise and distribute the load over the surface.

A number of charts comparing the relative economy of engine-driven vessels, geared turbines and electric propulsion showed the following water rates per shaft horsepower-hour. For the "Vespasian," with triple-expansion engines, the water rate was 19 lb.; with geared turbines, 16 lb.; and with electric drive, 12.7 lb. The "Cairngowan," with triple-expansion engines, developed a shaft horsepower-hour on 17.3 lb. of steam, and the "Cairnross," a sister ship with geared turbines, on 14 lb. It was estimated that either vessel equipped with electric drive would develop a shaft horsepower-hour on 11.77 lb. of steam. The above figures tend to prove the assertion made by Mr. Emmet that electric drive over triple-expansion engines will reduce the water rate about one-third.

In the discussion it was brought out that as induction motors cannot run above synchronous speed, the propellers cannot race. Even in a heavy sea, with the propellers entirely out of water there is no vibration or any indication of a change in speed. As to the proper fields for reduction gearing and electric drive, Mr. Emmet made the general statement that in all ships requiring above 15,000 to 20,000 hp., gearing would make a poor comparison. In vessels requiring 10,000 hp. and less and running at a low speed, reduction gearing would perhaps make the best showing. The field for electric drive is in large merchant ships and all battleships with the exception of torpedo boats and destroyers, where restrictions in weight prohibit its use.

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Guard Ash Piles—When the owner of a power plant has knowingly permitted children to play about a pile upon which hot ashes from the boilers are deposited, he is under a legal duty to either maintain a guard or give suitable warning to prevent injury to such children, according to a decision of the United States Circuit Court of Appeals, for the Sixth Circuit, in the case of O'Donnell vs. Escanaba Manufacturing Co., 212 "Federal Reporter," 648. In this case judgment was affirmed in favor of a ten-year old girl who was burned in undertaking to walk over a pile of hot ashes.

A Mandatory Statute—A law enacted by the Oregon Legislature in 1911, to promote the safety of electricians, requires dangerous wires to be completely insulated, prohibits intermingling of dead and live wires, requires the supports of live wires to be so designated that the presence of such wires shall be instantly apparent, and requires such wires to be so strung as not to endanger repairmen working near them, etc. Applying this law to an action for the death of a lineman who was electrocuted while working on a pole which supported uninsulated wires, the Oregon Supreme Court lately decided, in the case of McClaugherty vs. Rogue River Electric Co., 140 "Pacific Reporter," 64, that an employing electric company cannot excuse liability for failing to comply with such statutory requirements, by installing switches in such a location that electric current can be shut off while work is being done. The court says: "The requirements of the statute as to the safeguards enumerated are positive and mandatory. There are no alternatives."

Right to Enjoin Construction of Dam—That suit does not lie to enjoin the construction of a power dam when it is being erected under legislative authority is the gist of the decision of the North Carolina Supreme Court in the case of Tucker & Carter Rope Co. vs. Southern Aluminum Co., 81 "Southeastern Reporter," 771. The court said: "The defendant's dam is being constructed under express legislative authority, and is a lawful structure per se, and cannot be restrained as a public or private nuisance. If, in the course of its lawful operation, it may inflict injury upon the plaintiff, it is amply able to respond in damages. Whether the relief to which the plaintiff shall be entitled will be the recovery of damages or the abatement of the height of the dam is a matter which will arise when the facts are found; but certainly the courts will not stop the construction of the dam more than 18 months before its completion upon the allegation of the plaintiff, which is denied in the answer, that it will injure its property if built to the height that is proposed."

Effect of Washington Public Service Commission Law—As construed by the Washington Supreme Court in the recent case of Tacoma Railway & Power Co. vs. City of Tacoma, 140 "Pacific Reporter," 565, the Public Service Commission law of that state "deals only with the questions of safety, efficiency, rates and equality of public service. The power to grant a limited franchise is still in the city. No power was given to the public-service commission to grant, modify, or abrogate franchises or contracts arising out of franchises, except in regard to rates and the regulation of service in respect to its safety, efficiency and equality. It was not the purpose of the act to enlarge franchises, or to require the performance of acts being exercised under a franchise which could not be legally exercised, or for a longer period than such acts could be legally exercised." Hence, it is found that the law did not abrogate a condition in an electric franchise previously granted by the City of Tacoma to an electric company, providing that it should not furnish electricity for lighting purposes.

Cause of Turbine Failure

The "Journal of Electricity, Power and Gas" of Apr. 17 contains the finding of the board which investigated the recent turbine failures at the Fruitville plant of the Southern Pacific Co.

It appears that the trouble began by one of the turbines losing six blades of the impulse element. The load was shifted to the other turbine, but on the following day practically all the intermediate blading of the second machine let go. The first machine being open and under repair at this time, the service was crippled for several hours. Investigation showed the cause of the blade failure in the second machine to have been the rusting of the metal in which the blades are secured. This permitted some of the blades to come out and in turn rip out others, until the entire intermediate stage had been destroyed. It is believed that the rusting resulted from leakage of steam past the throttle when the machine was stationary. It is very difficult to keep the throttles absolutely tight, but arrangements have been made so that in the future this leakage will exhaust to the atmosphere instead of into the turbine casing. Moreover, rusting will be prevented by the introduction of brass lining strips, which the makers are now recommending with this type of turbine.

Ice Plants Not Immune from Accidents

The fact that the refrigerating industry in which chemicals and highly compressed gases are used in connection with tanks, piping and moving machinery is not immune from accidents is attracting the attention of municipal authorities to such an extent that regulations for installing and operating the plants have been drawn up and put into effect in many localities. No doubt, these regulations will have to be revised as experience is gained in their application, and in this respect they may be expected to have a history similar to that of analogous regulations applying to steam boilers. As in almost every other industry, the majority of the accidents that occur are avoidable, provided sound engineering principles are followed in the design, installation and operation of the plants. It follows, then, that the engineer who designs the plant and the man who supervises the installation should bear in mind the question of safety, and it is equally important to place competent men in charge of the operation of the plants, because the judgment and ability of the men are exceedingly important factors in preventing accidents.—"Travelers Standard."

Testing a Refrigerating System with Air

It is customary to test a refrigerating system with air pressure before charging with ammonia. This should be carefully done by experienced men to avoid an explosion by the ignition of the vapor from the lubricating oil, caused by the heat of compression.

A thin coating of lard oil should first be applied by hand to the walls of the compressor cylinders and the compressor allowed to run until the pressure reaches 100 lb. or more. It should then be stopped long enough to cool down, then started up again and operated until forty or fifty pounds of additional pressure is obtained, then stopped again. When sufficiently cooled it should once more be started, but at reduced speed, and stopped whenever the discharge pipe becomes hot enough to be uncomfortable to the hand. If these precautions are taken there is little chance of an explosion from internal causes during the test. The men should be kept away from the apparatus as much as possible, however, as there is always a possibility that an accident may occur through the failure of an imperfect joint or from unforeseen weakness in some other part.

Some Precautions Ice-Plant Engineers Should Observe

The operating engineer of a refrigerating plant should remember that he is subject to many of the hazards that are to be found in the ordinary power plant and also to some additional ones. For example, in compressing air he should never use a machine that has recently been used to compress ammonia, and in opening gage-cocks he should stand at the side rather than in front of the gage-glasses. Such precautions as standing at the side rather than in front of cylinders or compressors and refraining from calking pipes or tightening up fittings while they are under pressure are generally understood, but often disregarded. It is particularly dangerous to calk joints or tighten nuts or fittings under pressure. Many fatal accidents have been caused in this way.

However carefully a system is designed and installed, a certain amount of liquid is likely to accumulate, and its presence in the compressor is always a source of danger. The obvious remedy is to provide a properly located relief valve of sufficient capacity to permit the discharge of practically all the liquid present before the piston reaches the end of its stroke. There are cases where considerable difficulty may be experienced in equipping compressors with such devices, but the greater safety gained is well worth the trouble.

Every steam engine should be provided with a safety stop wholly independent of the ordinary governor. In case the governor fails to work properly and the engine starts to "race," the independent safety stop is supposed to operate as soon as the speed exceeds a predetermined limit, shutting off the steam, bringing the engine to a standstill, and preventing the bursting of the flywheel and other serious consequences.

Piston rings formerly caused considerable trouble, but ordinary snap rings are now used with satisfactory results, so far as accidents from this cause are concerned.—"Travelers Standard."

Ice-Making Plants in the United States

There are in the United States over 12,500 ice-making plants, having an aggregate annual output of about twenty million tons. This does not include the thousands of private refrigerating plants in small restaurants, meat markets, grocery stores and private dwellings. The principles of artificial refrigeration are being applied in more than 150 different industries, including among others mining, paper making, woolen and silk manufacturing, laundering, and tobacco manufacturing.

OBITUARY

JOSEPH G. GANNON

Joseph Charles Gannon, chief engineer of the Greenpoint Hospital, Brooklyn, N. Y., died Apr. 17 from pneumonia. He was 47 years of age and had long been a member of the National Association of Stationary Engineers.

ANDREW J. WILSON

Andrew Joseph Wilson, manager of the Lynn Canadian Refrigeration Co., and a consulting engineer, died Apr. 18, from heart failure. He was 39 years of age and had spent twenty years in Toronto, Can., where his death took place.

PERSONALS

John Sabin, who likes to recall that he is the man who sold the first Bundy trap something more than a quarter of a century ago, has been appointed general manager of the Nashua Machine Co., the manufacturer of the trap.

ENGINEERING AFFAIRS

The American Boiler Manufacturers' Association will hold its 1915 convention at the Lawrence Hotel, Erie, Penn., on June 21, 22 and 23. Among other matters the convention will consider the standardization of a uniform cost system and of material, workmanship and terms of payment clauses in specifications. The committee on the A. S. M. E. Boiler Code will report and ways and means will be discussed for securing the adoption of the code in the several states. The attendance of all boiler manufacturers in the United States and Canada is requested. Those expecting to be present should notify the secretary, J. D. Farasey, East 37th St. and Erie Railroad, Cleveland, Ohio.

The National District Heating Association will hold its seventh annual convention on June 1, 2 and 3 at the Hotel Sherman, Chicago. The following papers will be presented: "Commercial End of the Heating Business," by C. F. Oehlman,

Denver Gas & Electric Co.; "Operating Experience with Bleeder Type Turbines," by F. W. Laas, chief engineer, Iowa Railway & Light Co., Cedar Rapids, Iowa; "The Hot Water Heating System at the Grand Central Terminal," by W. G. Carlton, New York City; "A Pressure Study of a Steam Distribution System," by C. C. Wilcox, engineer, Hodenpyl Hardy Co., Jackson, Mich.; and "Exhaust Steam vs. Live Steam for Heating," by George W. Martin, New York Service Co., New York City.

NEW PUBLICATIONS

ELEMENTARY ELECTRICITY AND MAGNETISM. By W. S. Franklin and Barry MacNutt. Published by the MacMillan Co., New York, 1914. Size, 4½x7½ in; 174 pages; illustrated. Price, $1.25 net.

A simple and well-illustrated presentation of the principles of electricity, studied from its effects rather than from the theoretical standpoint. The pump analogy is used to advantage in describing electromotive force and resistance. While the book is intended primarily for the student, its usefulness to the practical man might have been enhanced had more of the illustrations been selected from modern commercial apparatus.

HEAT ENGINEERING. By Arthur M. Greene, Jr., Professor of Mechanical Engineering, Rensselaer Polytechnic Institute. Published by the McGraw-Hill Book Co., Inc., New York. Cloth; 462 pages; 6x9 in.; 198 illustrations. Price, $4.

This volume is announced as a textbook of applied thermodynamics for engineers and technical students. The first chapter contains a brief review of the theory of thermodynamics. Chapters follow on heat transmission, air compressors, the steam engine, the steam turbine, condensing apparatus, internal-combustion engines and refrigeration. Each chapter is concluded by a series of topics and problems. The topics consist of a series of questions relating to the text and the problems (without answers) illustrate its use. The book is decidedly unusual in its treatment of the steam boiler. The combustion of fuel in boilers is briefly described in the section relating to internal-combustion engines, but otherwise a consideration of the steam boiler, its theory, design and performance, is missing. As half of the book applies to apparatus using steam, the omission seems unexplainable. With this exception the book appears to present a useful outline of applied thermodynamics.

ENGINEERING ECONOMICS. By John C. L. Fish, Professor of Railroad Engineering, Leland Stanford, Jr., University. Published by the McGraw-Hill Book Co., Inc., New York. Cloth; 217 pages; 6x9 in. Price, $2.

The title of a book is sometimes descriptive of its contents. Professor Fish's treatise, in spite of its title, does not attempt to set forth laws of wealth peculiar to engineering, but it does explain the factors on which depend the long-run least cost of engineering structures. The book deals mainly with the economic selection of the means of accomplishing engineering ends, and this selection is defined as the choice based on the long-run least cost. The opening chapters are devoted to the derivation of formulas for calculating simple and compound interest and to an explanation of sinking funds, capitalized value and other relevant financial terms. The essential components of first cost, such as investigation, promotion and construction expenses, are next outlined; and scrap value, depreciation and amortization are defined. The application of these terms is shown in a chapter on the elements of yearly cost of service. The method of figuring amortization and interest charges is clearly and completely handled, but the attention paid to operation and maintenance expenses seems inadequately brief. No doubt, the author emphasized the financial and accounting problems, believing that the engineer needed no information on material and labor expenditures. The elements described are illustrated by fifteen numerical examples, four of which apply to the power plant. A useful feature is the list of depreciation rates accepted by various legal authorities, in which apear a number of items of power-plant equipment. There are also a number of references to published cost data and to estimating methods used in designing engineering structures. While the book seems to have been written chiefly for the designing, it should prove useful to any engineer requiring a working knowledge of the principles underlying cost-of-operation calculations.

ENGINEERING EXPERIMENT STATION BULLETIN

Volume 10 of the "Bulletins of the Engineering Experiment Station," University of Illinois, has recently come from the press, bound in half-leather and containing reports of the work at the experiment station from September, 1913, to April, 1914. The subjects covered are: The Strength of I-beams in Flexure, by H. F. Moore; Coal Washing in Illinois, by F. C. Lincoln; The Mortar-Making Qualities of Illinois Sands, by C. C. Wiley; Tests of Bond between Concrete and Steel, by D. A. Abrams; Magnetic and Other Properties of Electrolytic Iron Melted in Vacuo, by T. D. Yensen; Acoustics of Auditoriums, by F. R. Watson; and the Tractive Resistance of a 28-Ton Electric Car, by H. H. Dunn.

BUSINESS ITEMS

The M. W Kellogg Co., New York, has moved its offices into larger quarters at 90 West St.

E. G. Calles Co., Chicago, Ill., has been appointed agent for the S-C Regulator Co., Fostoria, Ohio, for the Chicago territory.

The McClave-Brooks Co., Scranton, Penn., has opened a Boston office in the Equitable Building, No. 202, in charge of S. C. Smith, manager.

The Pittsburgh branch office of the Bristol Co., Waterbury, Conn., has been moved from 1670 Frick Annex into better quarters at 832 Frick Building. R. B. Anthony is district manager.

The Wilson-Snyder Manufacturing Co. and the Wilson-Snyder Centrifugal Pump Co., of Pittsburgh, Penn., have opened a branch office at 52 Vanderbilt Ave., New York City, in charge of A. H. Sherwood.

The general sales department of the Nashua Machine Co. will hereafter be located in the principal office of the company, in Nashua, N. H. A Boston office will be maintained for New England business, in charge of E. M. Stevens, who has been associated with the business for many years.

M. N. MacLaren, New York manager of the Nordberg Manufacturing Co., of Milwaukee, Wis., builder of Corliss engines, uniflow engines, poppet-valve engines, high-compression oil engines, air compressors, hoisting engines, blowing engines, electric hoists, pumping engines, steam stamps, etc., announces the removal on Apr. 26 of the New York office from 42 Broadway to the new Equitable Building, 120 Broadway.

The C. W. Hunt Co., Inc., owing to increasing business, has moved its New York office from 45 Broadway, where it has been for 28 years, to the new building of the Adams Express Co., 61 Broadway. It will occupy a suite of offices on the 11th floor, which will give it much better facilities for transacting business. The company is a large manufacturer of coal-handling machinery, conveying machinery and small motor trucks.

The Wright Manufacturing Co. (alarm water columns, Emergency and Victor steam traps, Cyclone exhaust heads), the Austin Separator Co. (steam and oil separators), the Murray Specialty Mfg. Co. (Murray automatic boiler-feed regulators) have moved from 55-59 Woodbridge St., West, to larger and better quarters at 97-101 Woodbridge St., West, Detroit, Mich. The Murray Co. has just issued an attractive catalog, which can be had on application to the new address.

The Bruce-Macbeth Engine Co., Cleveland, Ohio, has recently made the following shipments: One 100-hp. natural-gas engine to the Fedders Manufacturing Co., Buffalo, N. Y.; one 350-hp. natural-gas engine and Steam Process to the Mansfield Milling Co., Mansfield, Ohio; one 150-hp. natural-gas engine to the Galion Iron Works & Manufacturing Co., Galion, Ohio; one 125-hp. natural-gas engine to the Setter Brothers Co., Cattaraugus, N. Y.; one 150-hp. natural-gas engine to the Dunn-Taft Co., Columbus, Ohio; one 150-hp. natural-gas engine to the Fostoria Glass Co., Moundsville, W. Va.; two 90-hp. natural-gas engines to the Brookville Glass & Tile Co., Brookville, Penn.

Kerr Turbine Co., Wellsville, N. Y., is distributing Bulletin No. 51, "Economy Geared Turbines," which explains the great advantages often obtained by interposing gears between turbine and driven generator, pump, blower or pulley, and also explains the new method by which Economy turbine gears are so accurately hobbed that no grinding or polishing is necessary for finish. A copy of this bulletin will be sent on request. Recent sales made by the Kerr Turbine Co. include the following: City of Atlantic City, N. J., 18,000,000-gal. Economy turbo-pump; City of Baltimore, 500-kw. Economy turbo-generator; City of Williamsport, Penn., 425 hp. turbine for driving a pump; City of Youngstown, Ohio, two 250-kw. turbo-alternators; dredge "Columbia," Port of Portland, Ore., two 1000-hp. geared turbines; Swift & Co., Chicago, 3 turbine units; Christian Moerlein Brewing Co., Cincinnati, 300-kw. turbo-generator; Carnegie Steel Co., Farrell, Penn., 125-hp. turbine; Jones & Laughlin Steel Co., Woodlawn, Penn., 325-hp. turbine; National Tube Co., Christy Park Works, McKeesport, Penn., 350-hp. turbine. Export orders include East Hull Gas Co., Groves, England; Corporation Gas Works, Birkenhead, England; and Armour de la Plata, Argentine.

The Flow of Steam from one vessel to another through an orifice with parallel sides increases as the pressure difference increases, down to 58 per cent. of the absolute initial pressure. A greater pressure difference does not affect the velocity, even though discharging into a perfect vacuum. For example, steam at 100 lb. pressure will increase in velocity as the pressure against which it discharges diminishes down to 58 lb., then the velocity of the flow will remain constant no matter how much the receiver pressure may be reduced—even to a perfect vacuum. Therefore, steam at approximately 25½ lb. discharging into the atmosphere has attained the maximum velocity possible in such a nozzle, which is 1470 ft. per sec., because 58 per cent. of 25½ equals 14.7, or ordinary atmospheric pressure.